Area Wide System Performance Prediction from Environmental and Acoustic Fields

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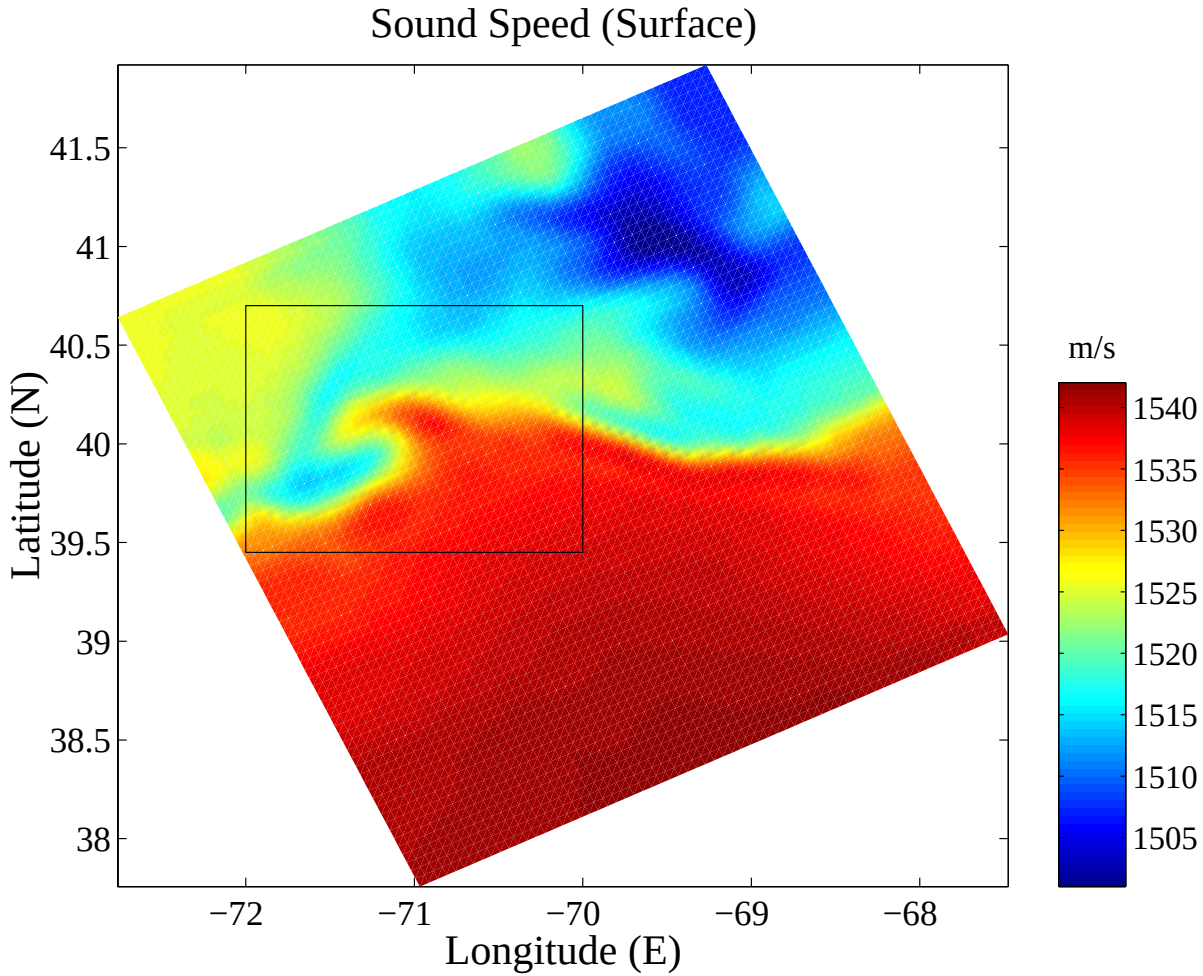
Outline

(Note: Narrative of entire presentation can be located after the "conclusion" slide)

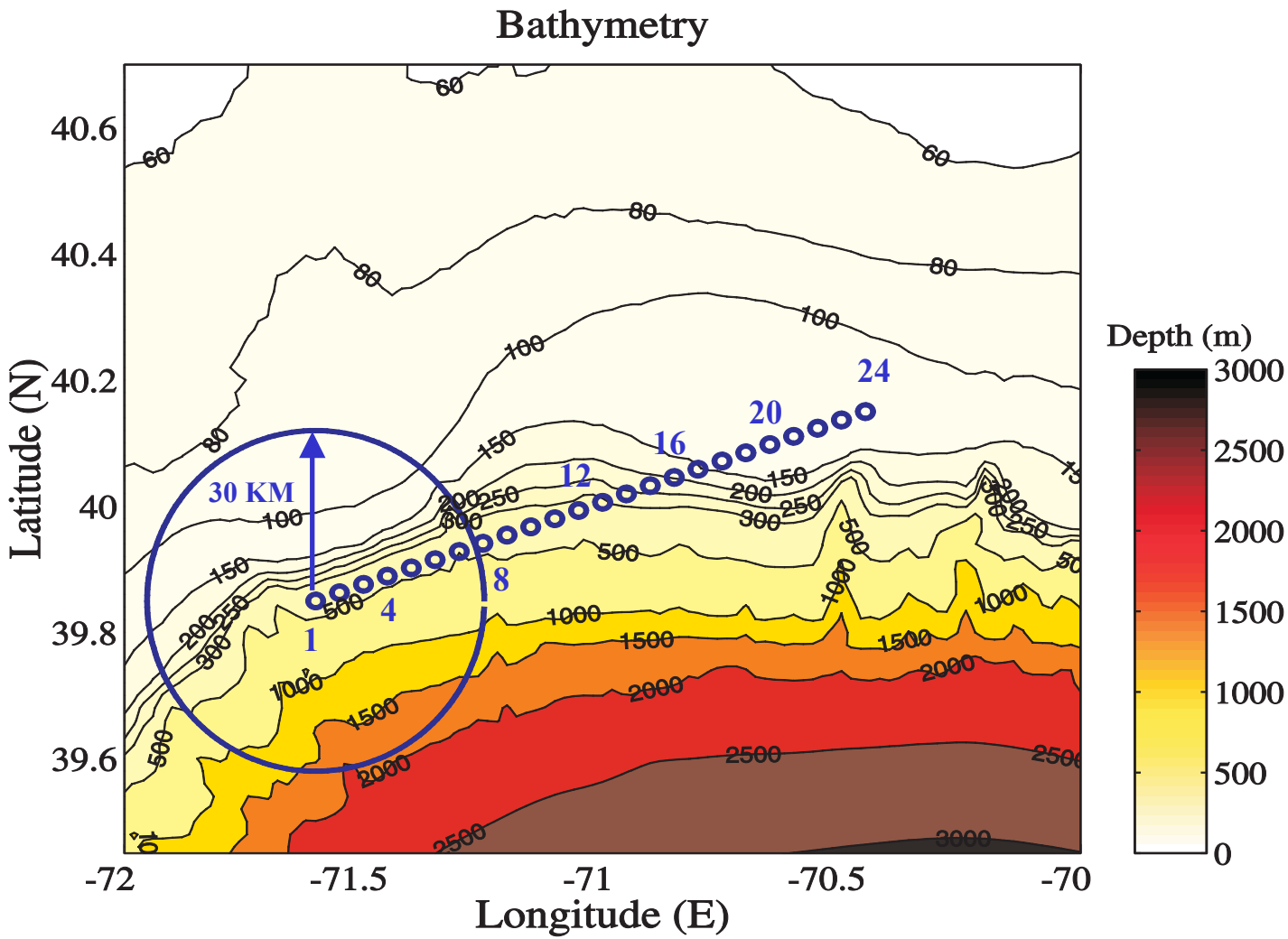
- Overall Description of Area Wide Performance Prediction
- Environments
- Environmental Effects on Sound Transmission
- Minimum Detection Level
- Results
- Conclusion and Discussion of Relevance to Uncertainty

Environment

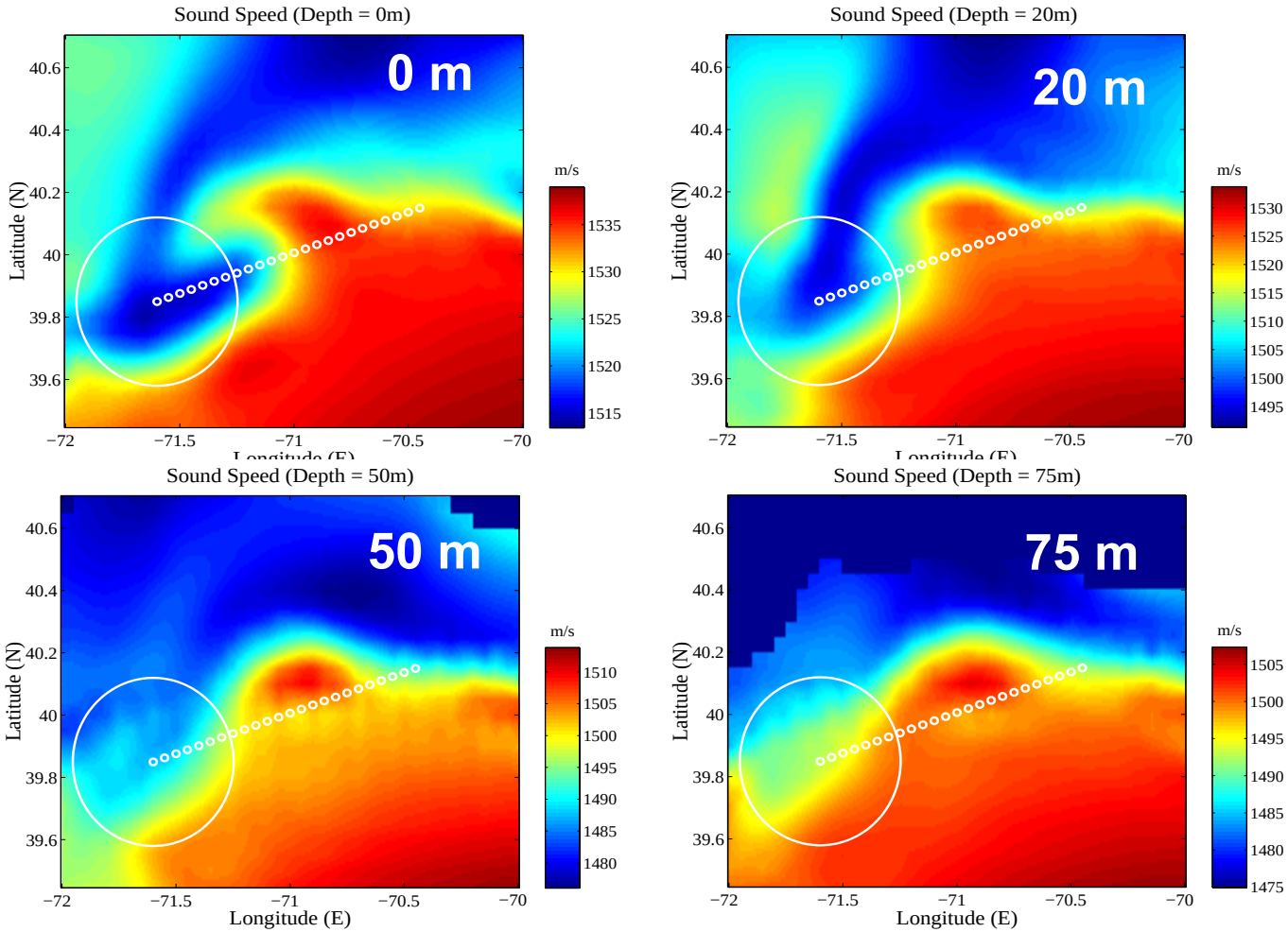
Surface Sound Speed Distribution



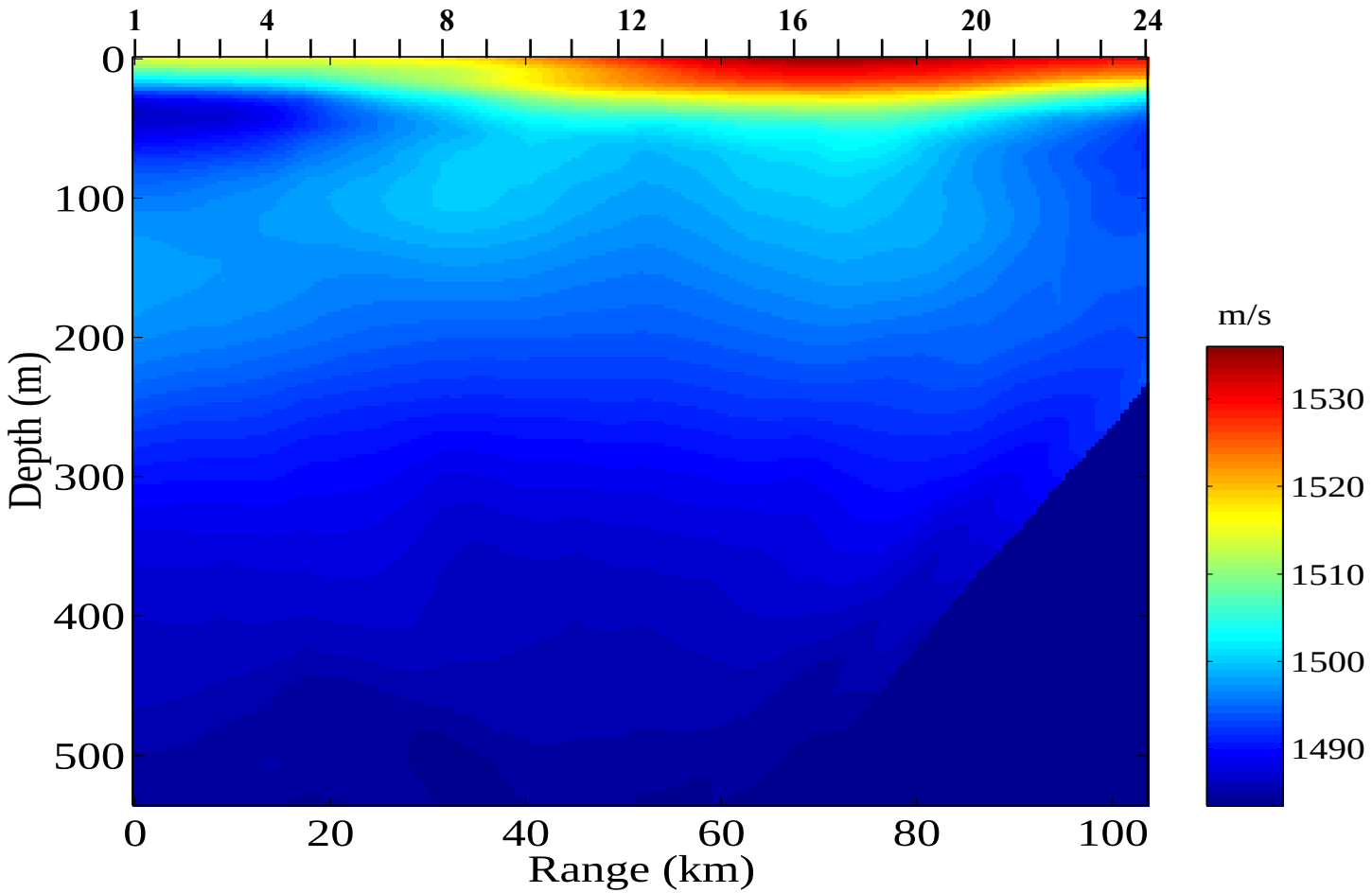
Bathymetry


Bathymetry
Latitude (N)
Longitude (E)
40.6
40.4
40.2
40
39.8
39.6
-72
-71.5
-71
-70.5
-70
30 KM
1
4
8
12
16
20
24
Depth (m)
3000
2500
2000
1500
1000
500
0

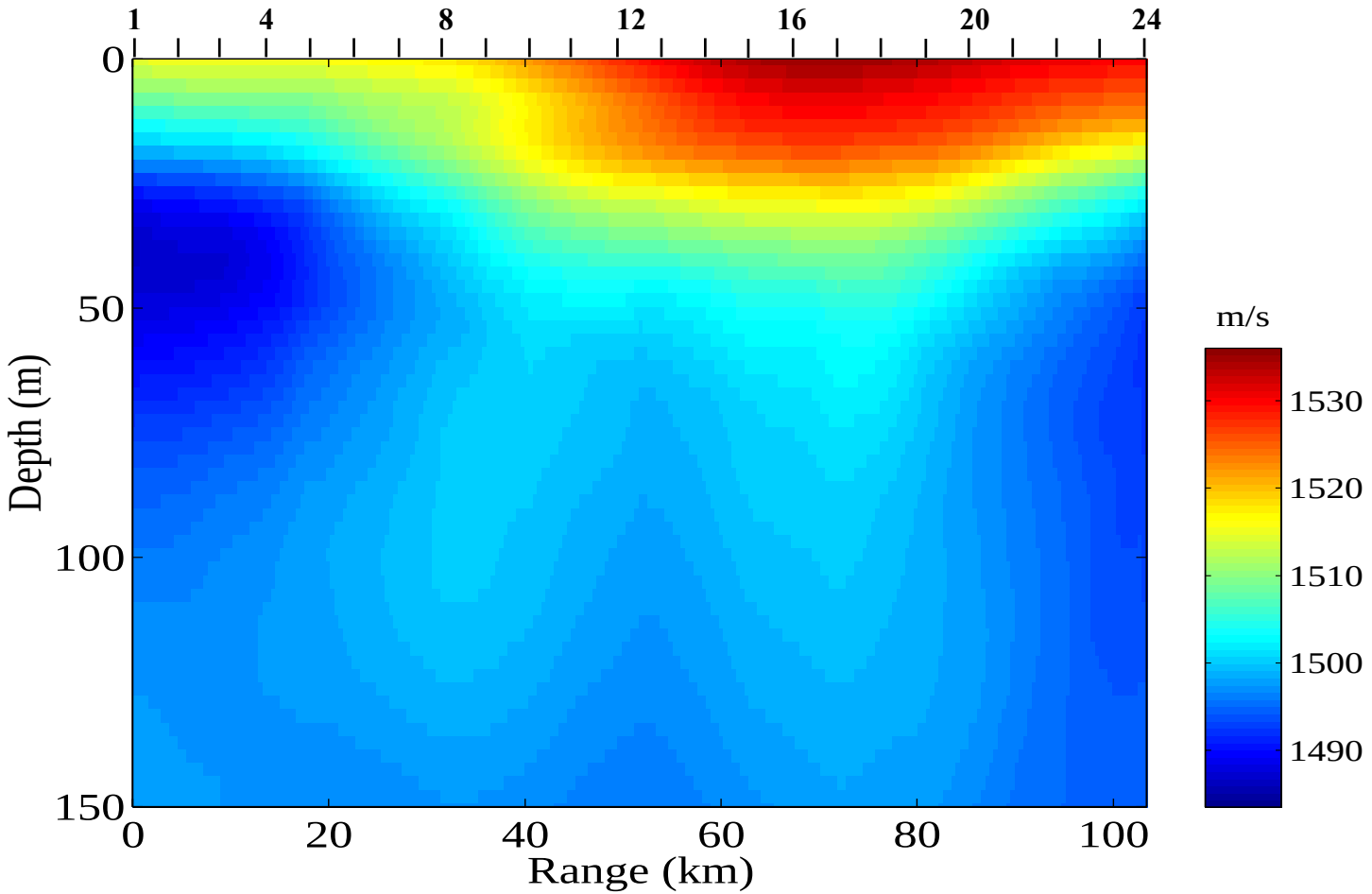
Sound Speed Distributions with Depth



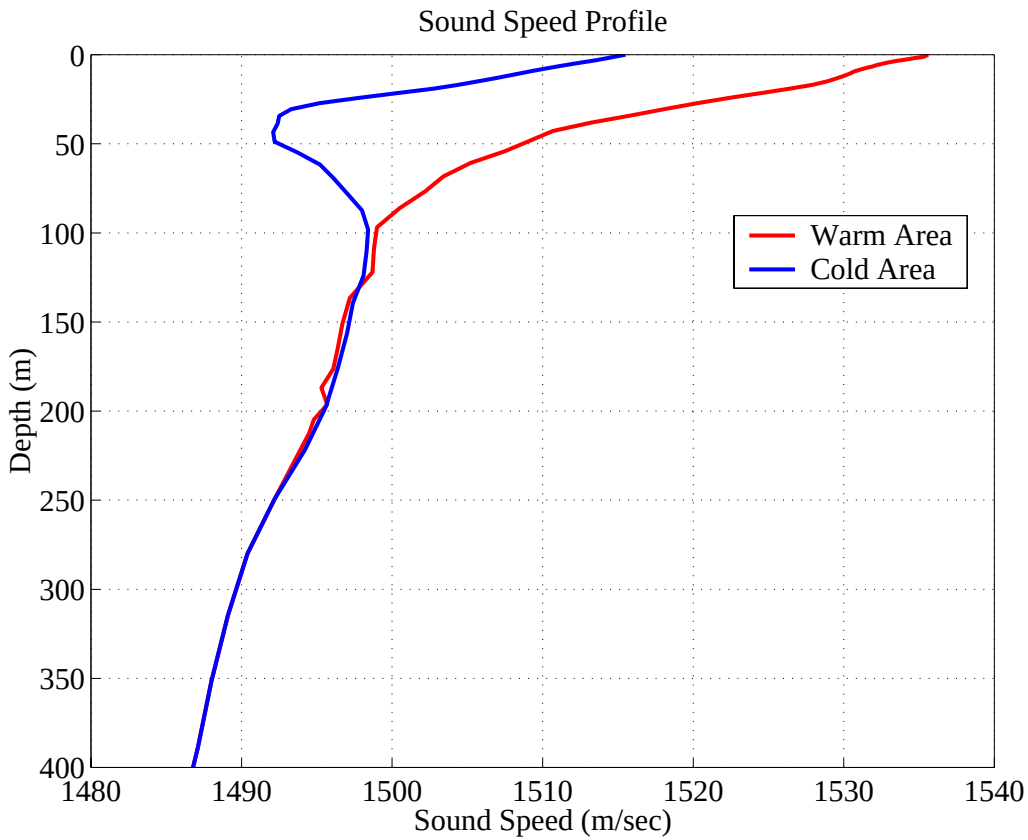
Sound Speed Distribution
(Vertical Section along the Track)



Sound Speed Distribution
(Vertical Section along the Track)

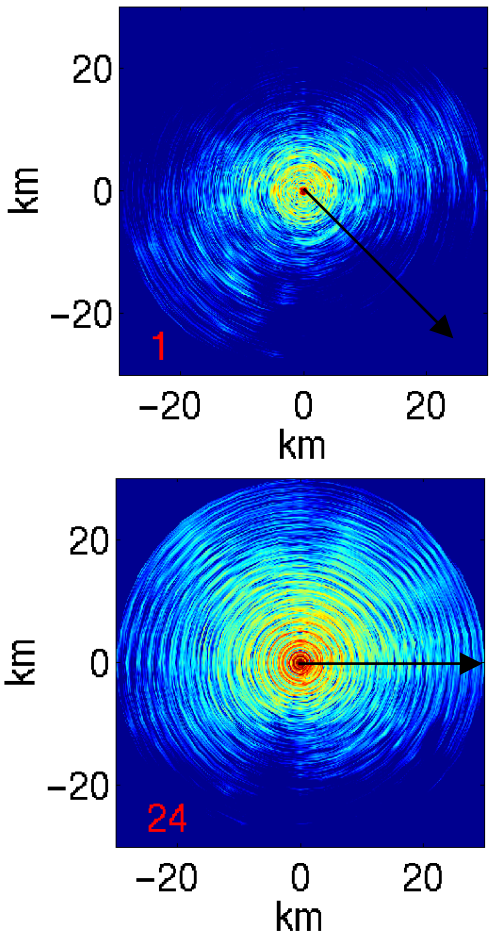


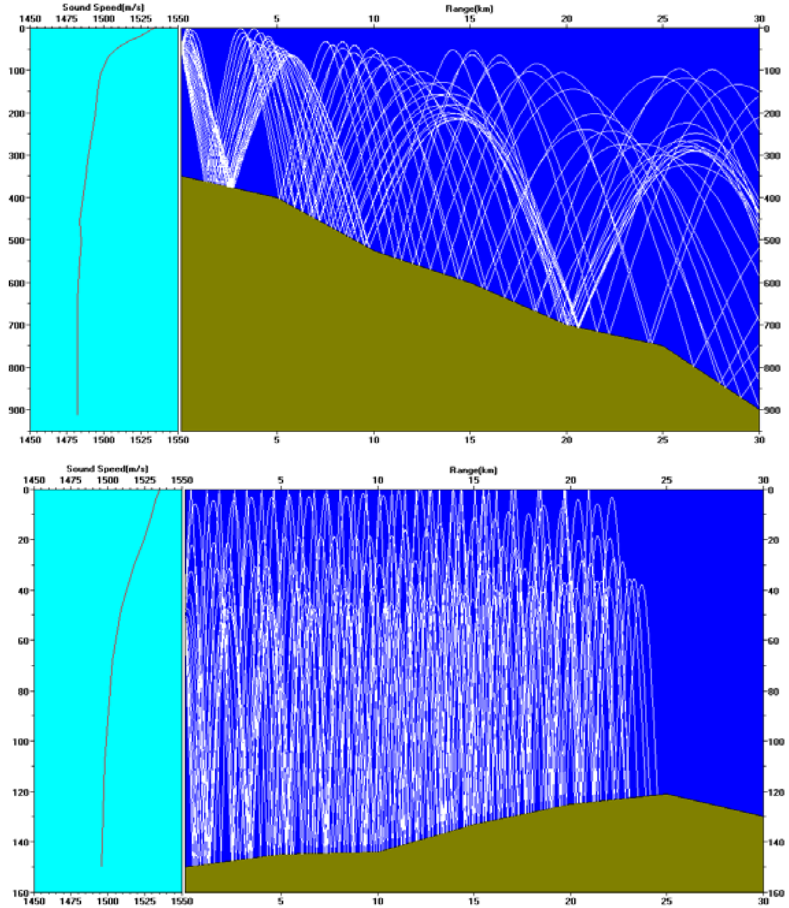
Warm/Cold Water Sound Speed Profiles



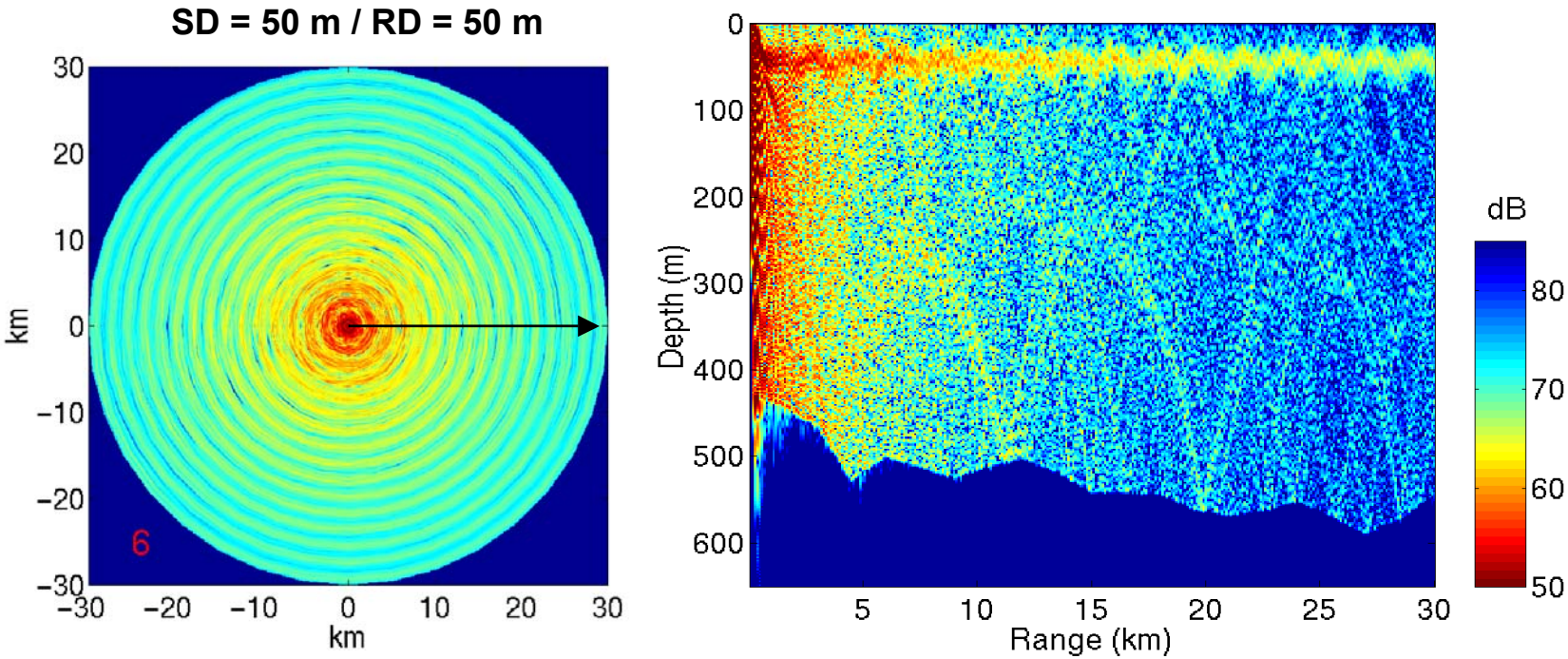
Environmental Effects on Sound Transmission

Sound Transmission
(Bathymetry Effect)



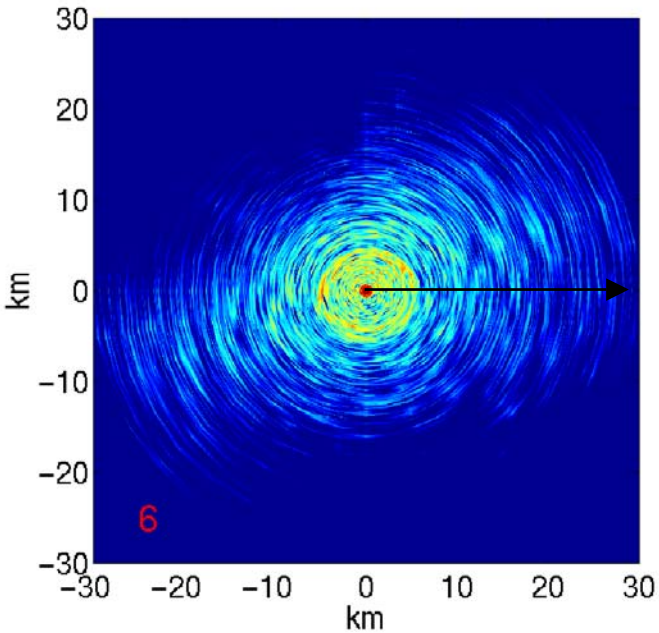


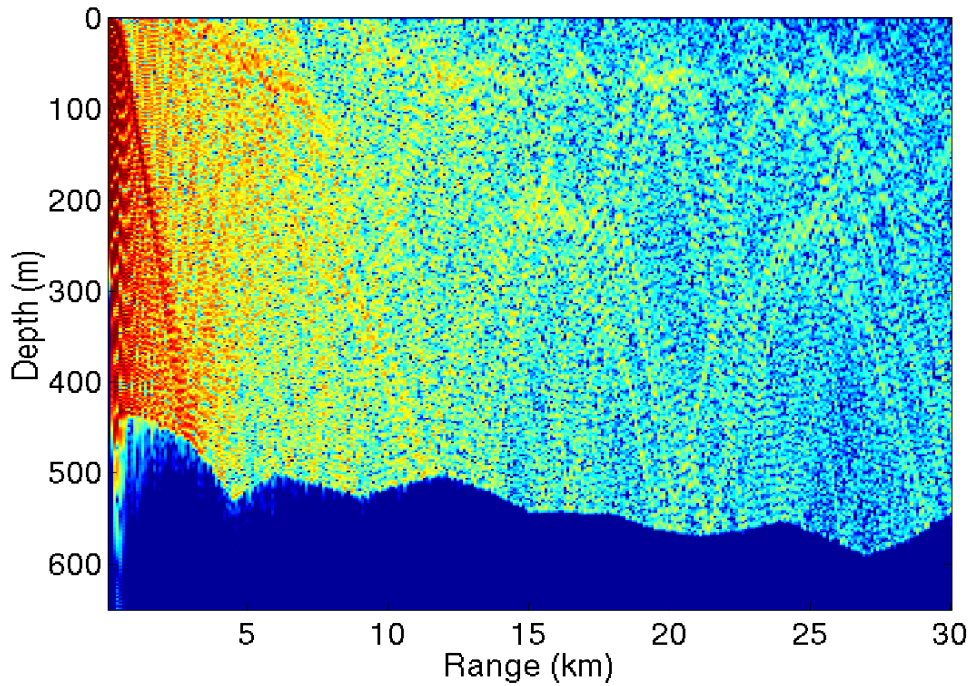
Sound Transmission
(Cold Water)



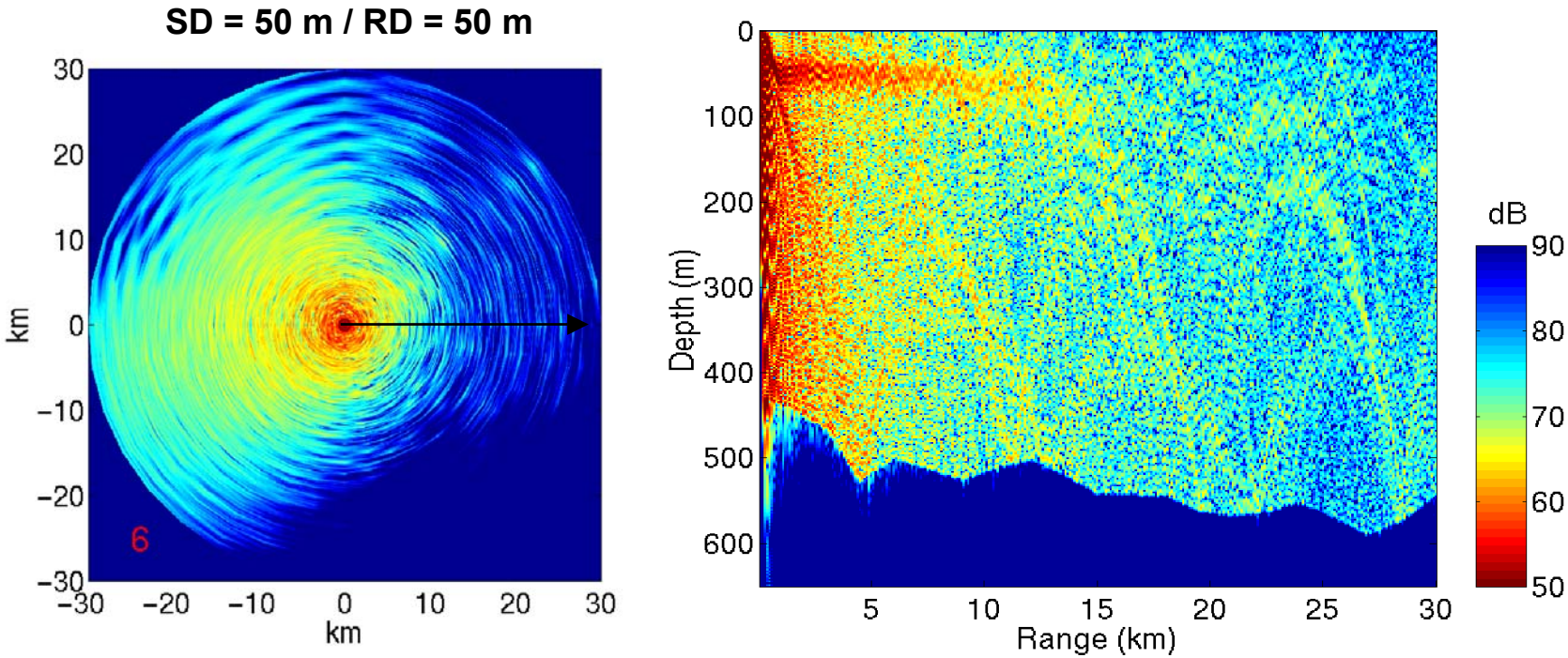
Sound Transmission
(Warm Water)

SD = 50 m / RD = 50 m





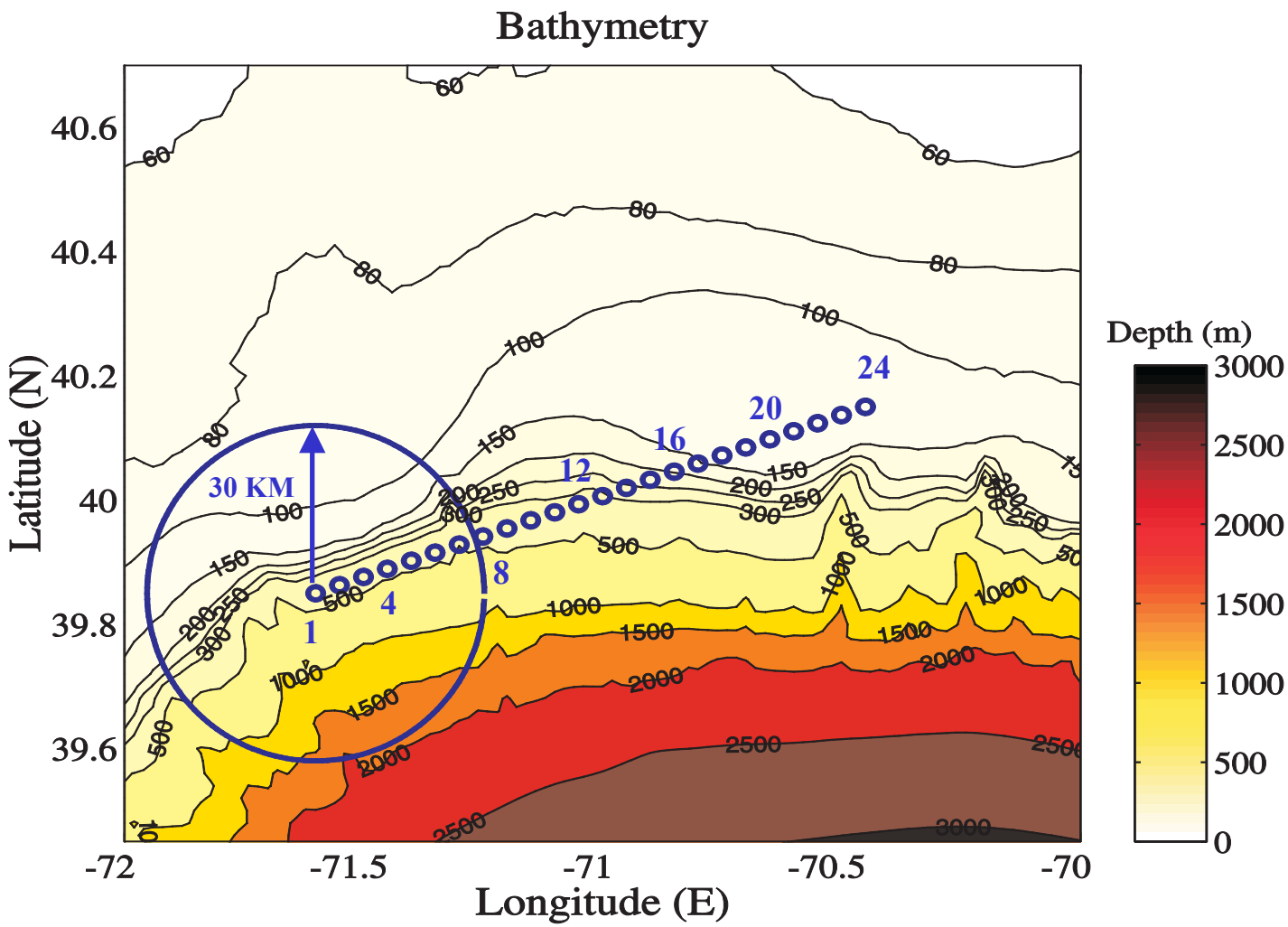
Sound Transmission
(Range-Dependent)



Transmission Loss along the Towing Ship Track

- Real Ocean : full range-dependent profile
- Cold water
- Warm Water
- RI Profile : SSP measured at ship position
- 2 Profile : warm (>1522 m/s), cold (<1522 m/s)

Bathymetry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30 KM
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8
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16
20
24
Depth (m)
3000
2500
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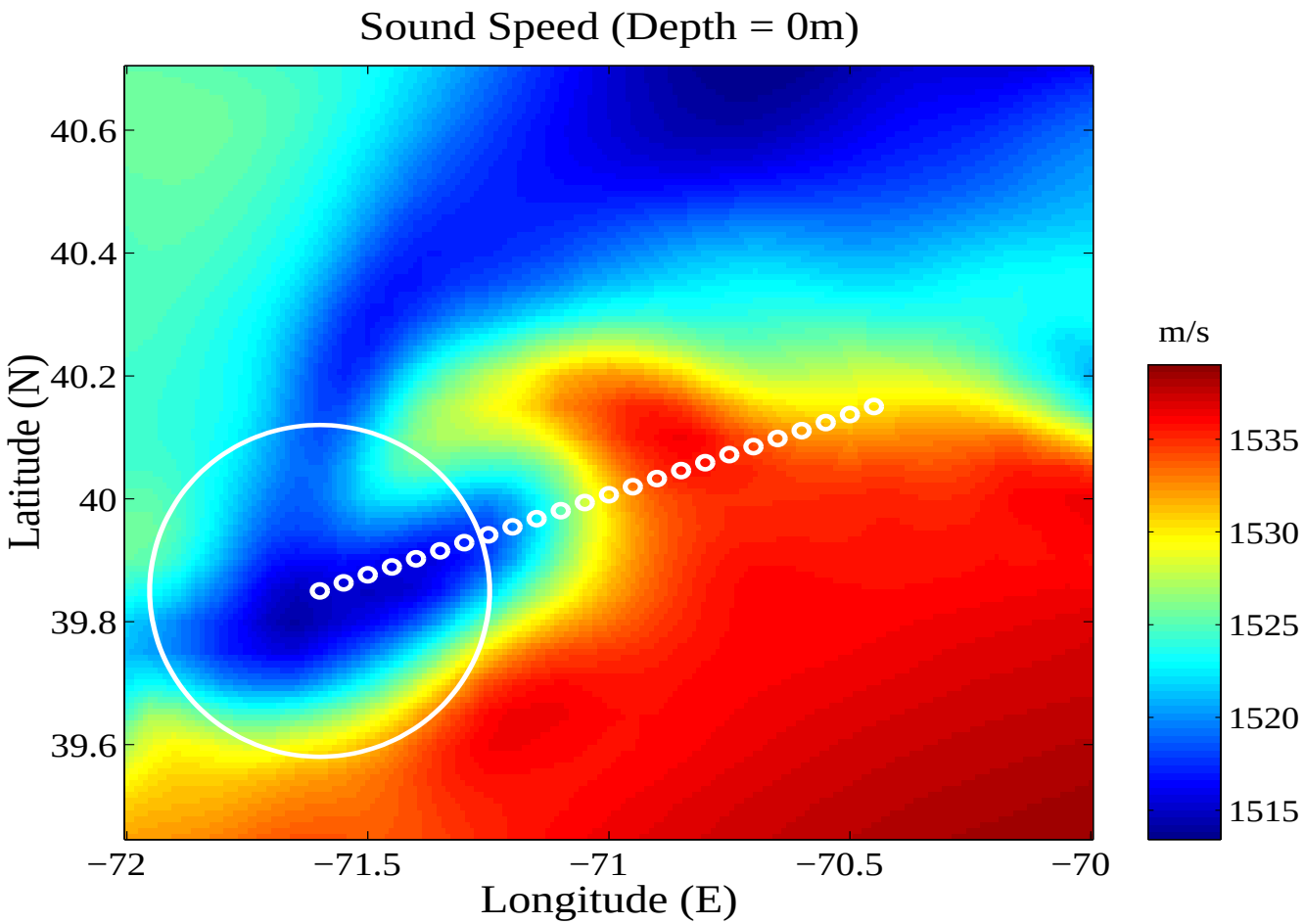
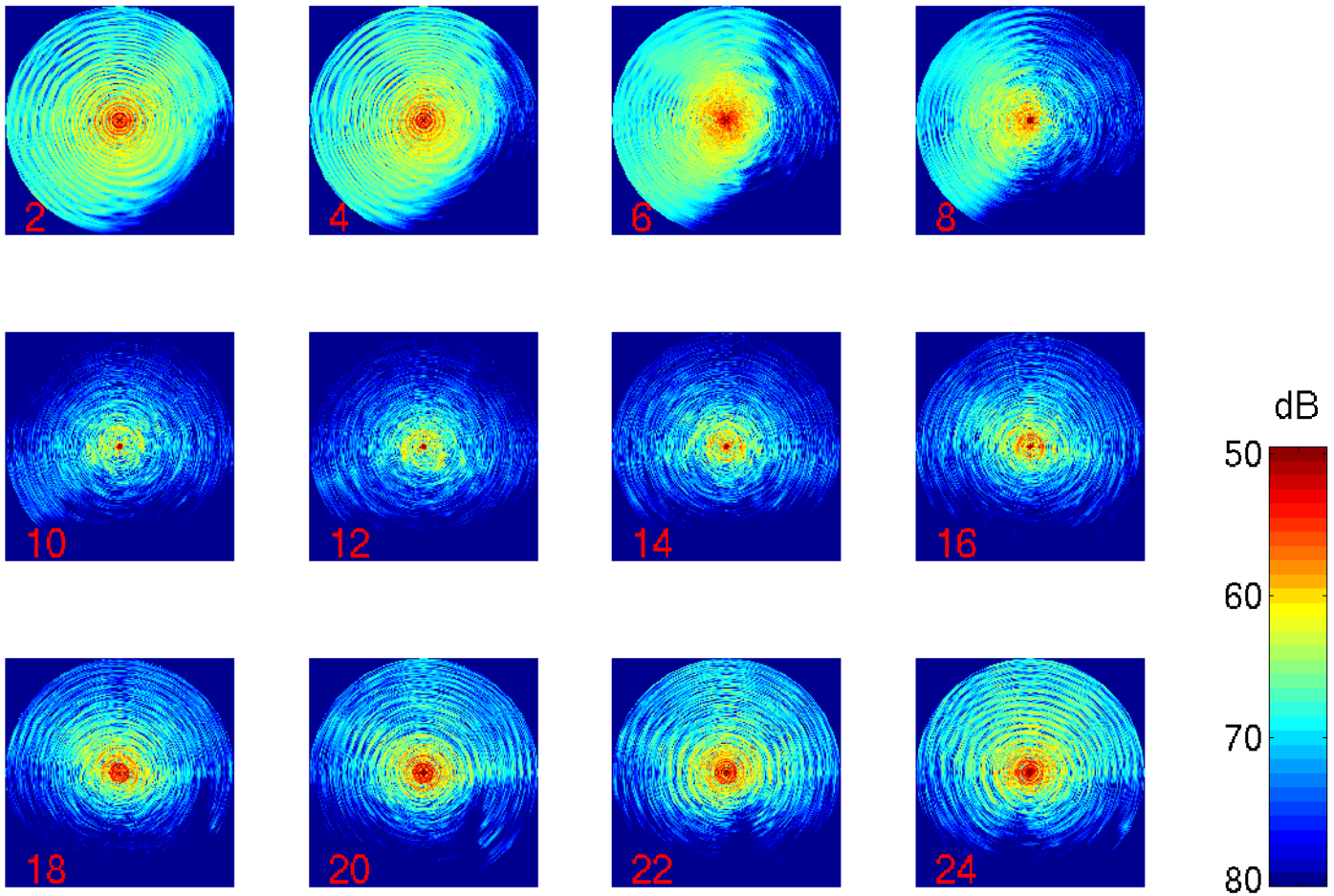
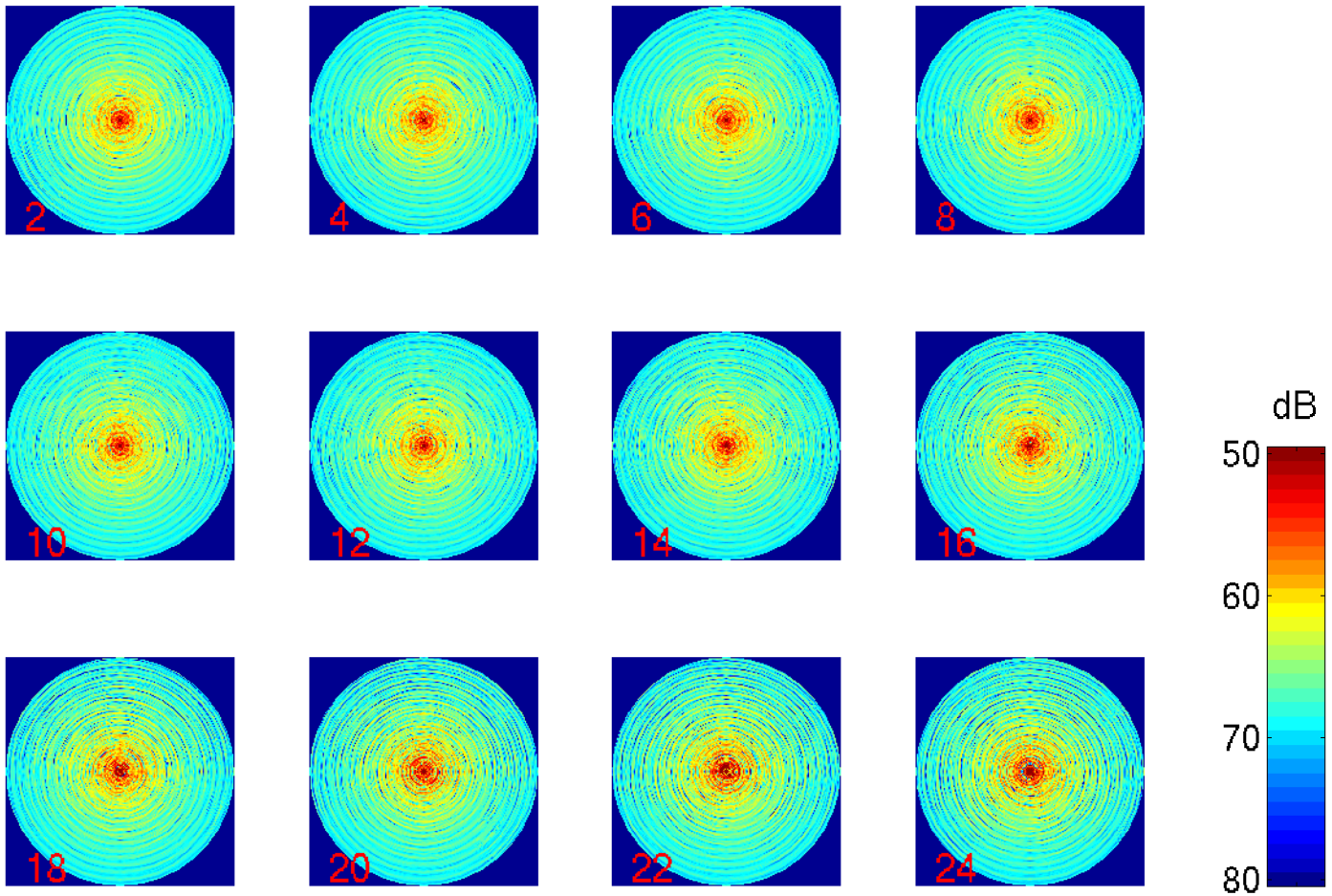
Surface Sound Speed



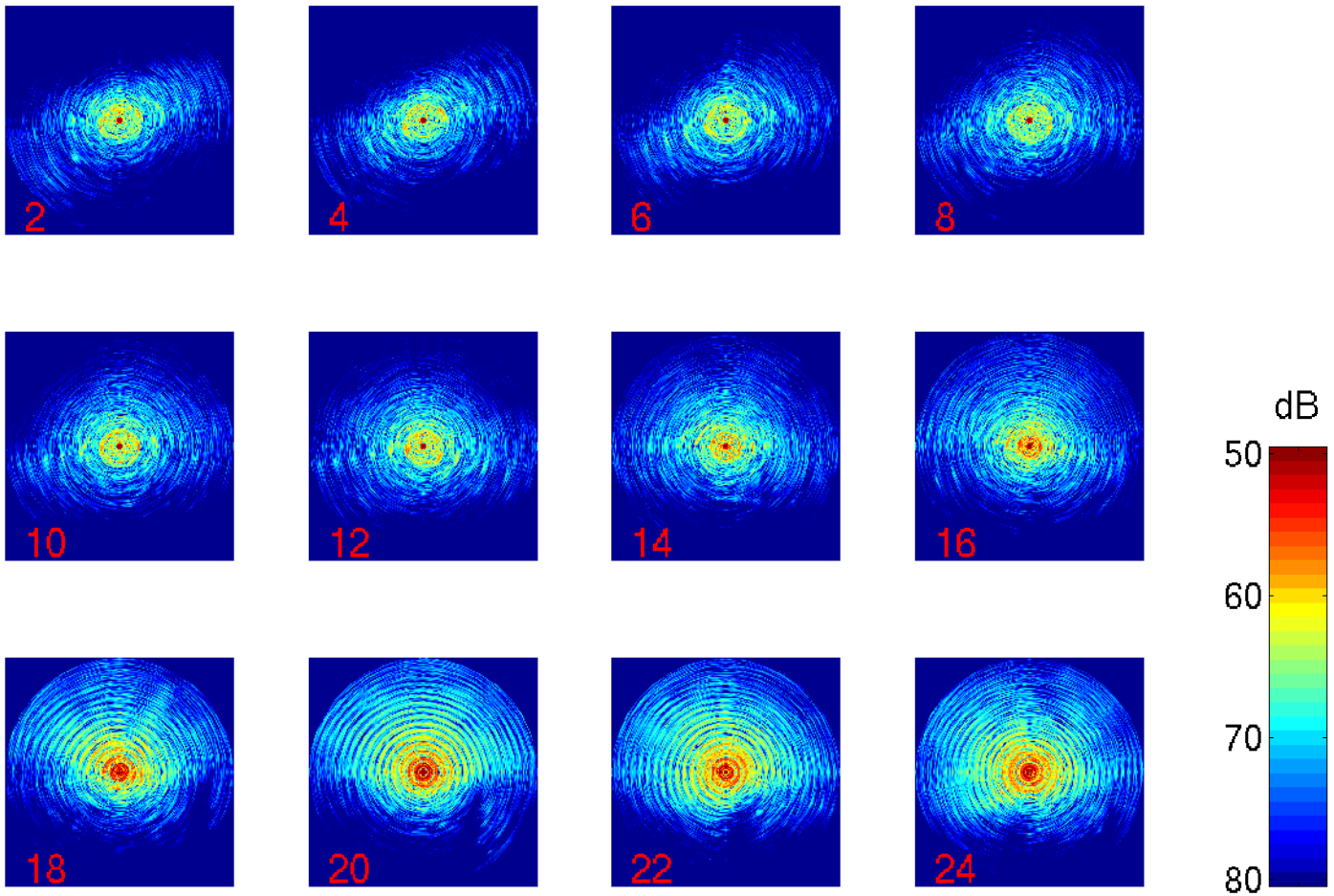
Transmission Loss (Real Ocean)



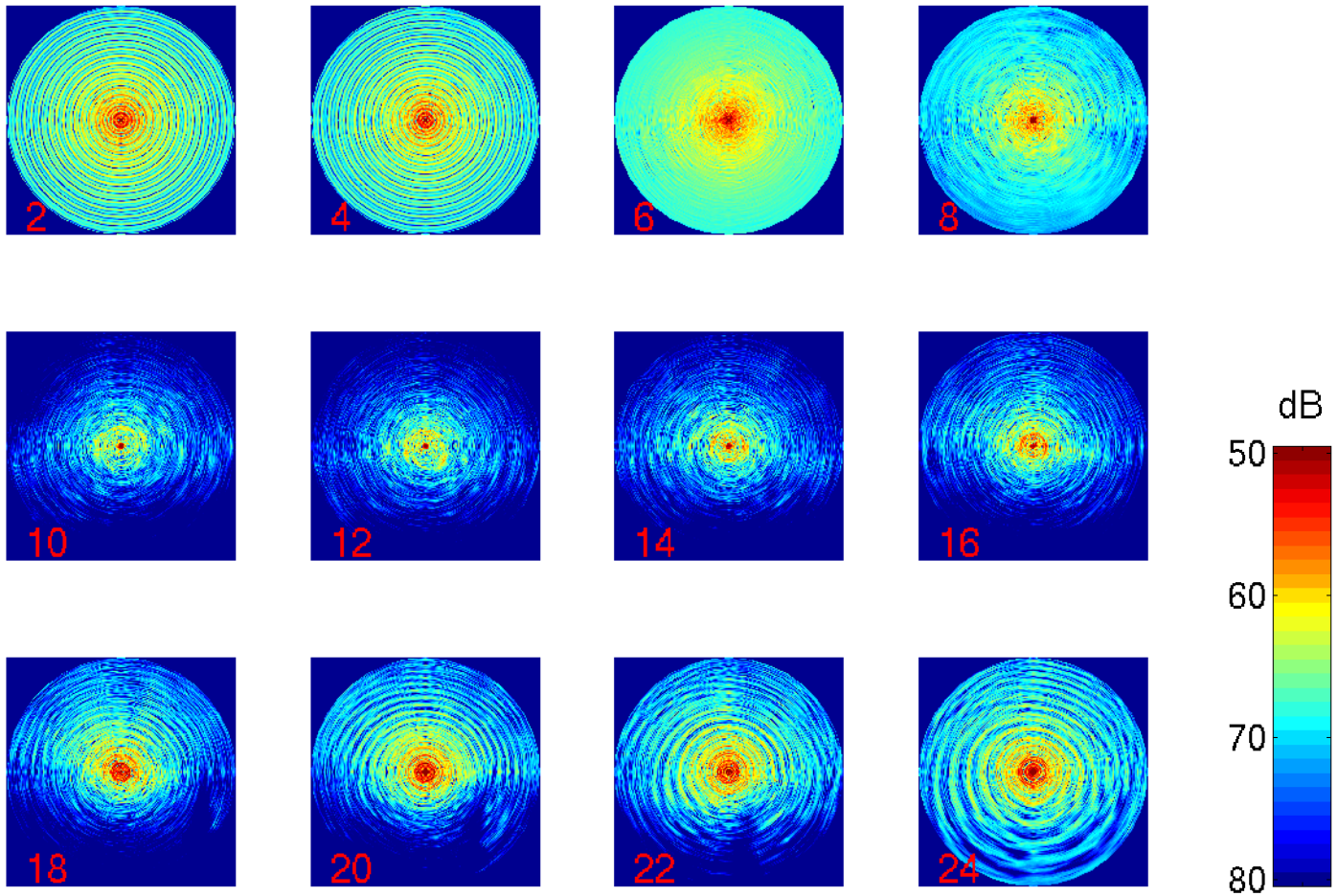
Transmission Loss (Cold Water)



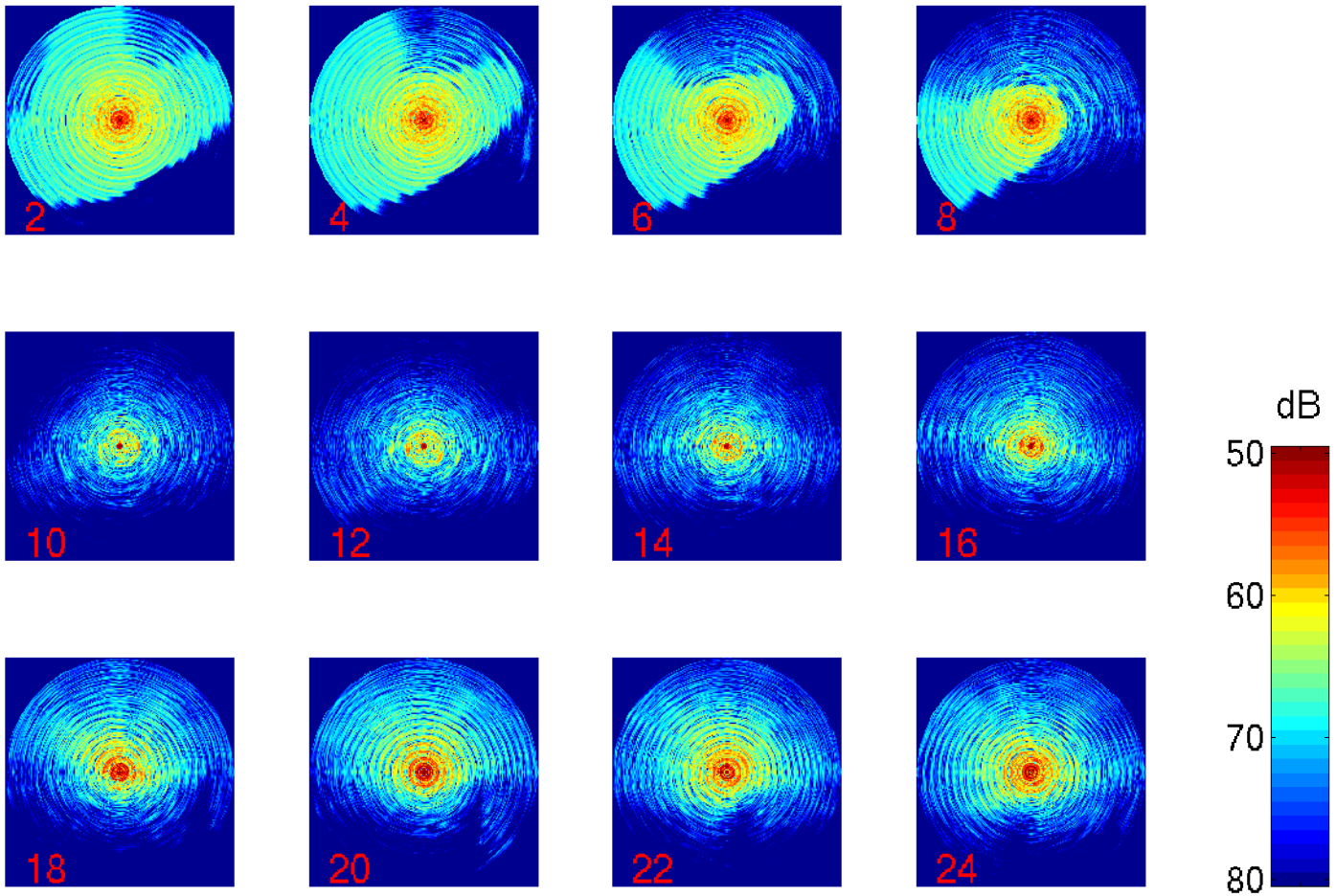
Transmission Loss (Warm Water)



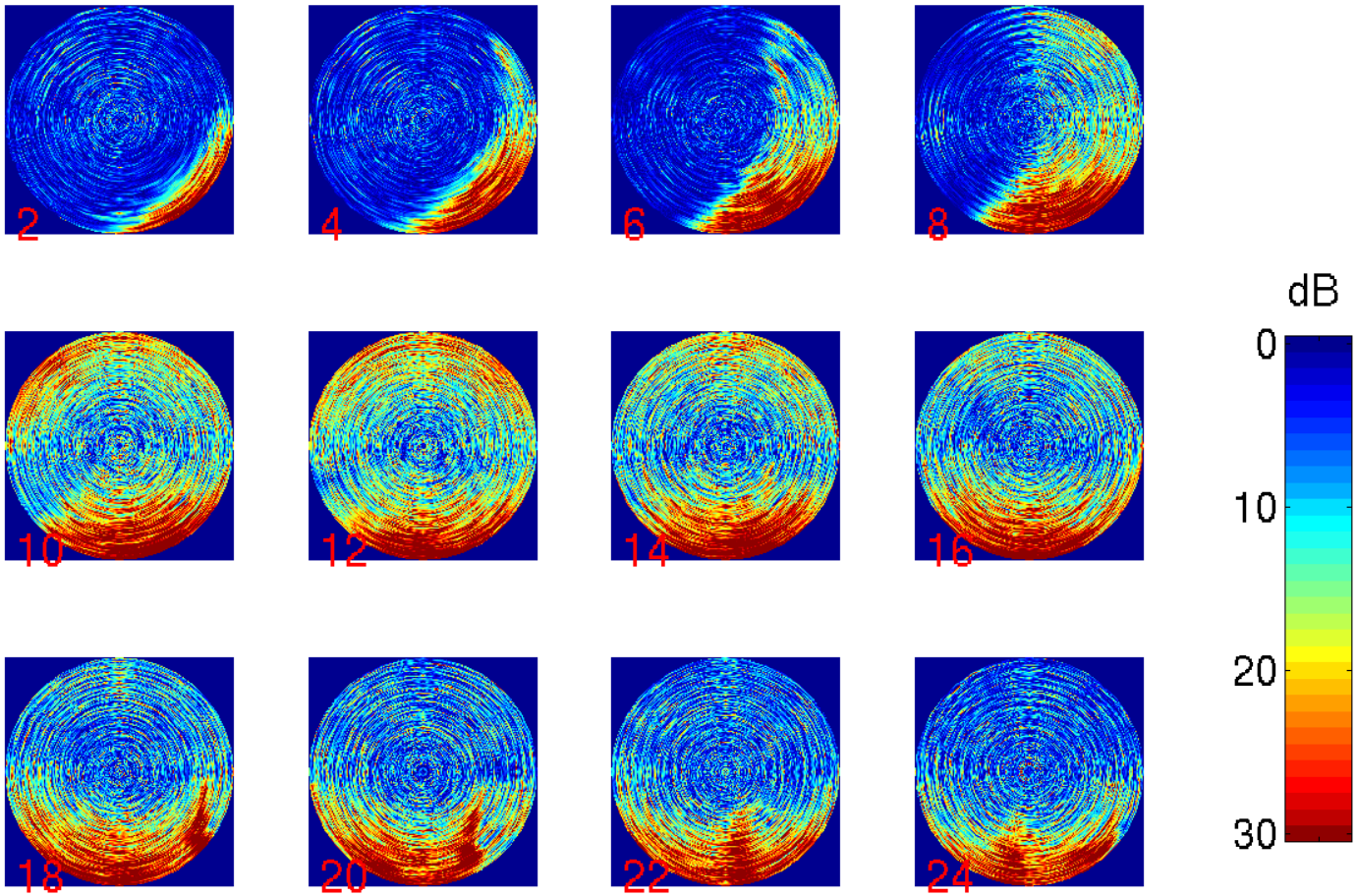
Transmission Loss (RI Profile)



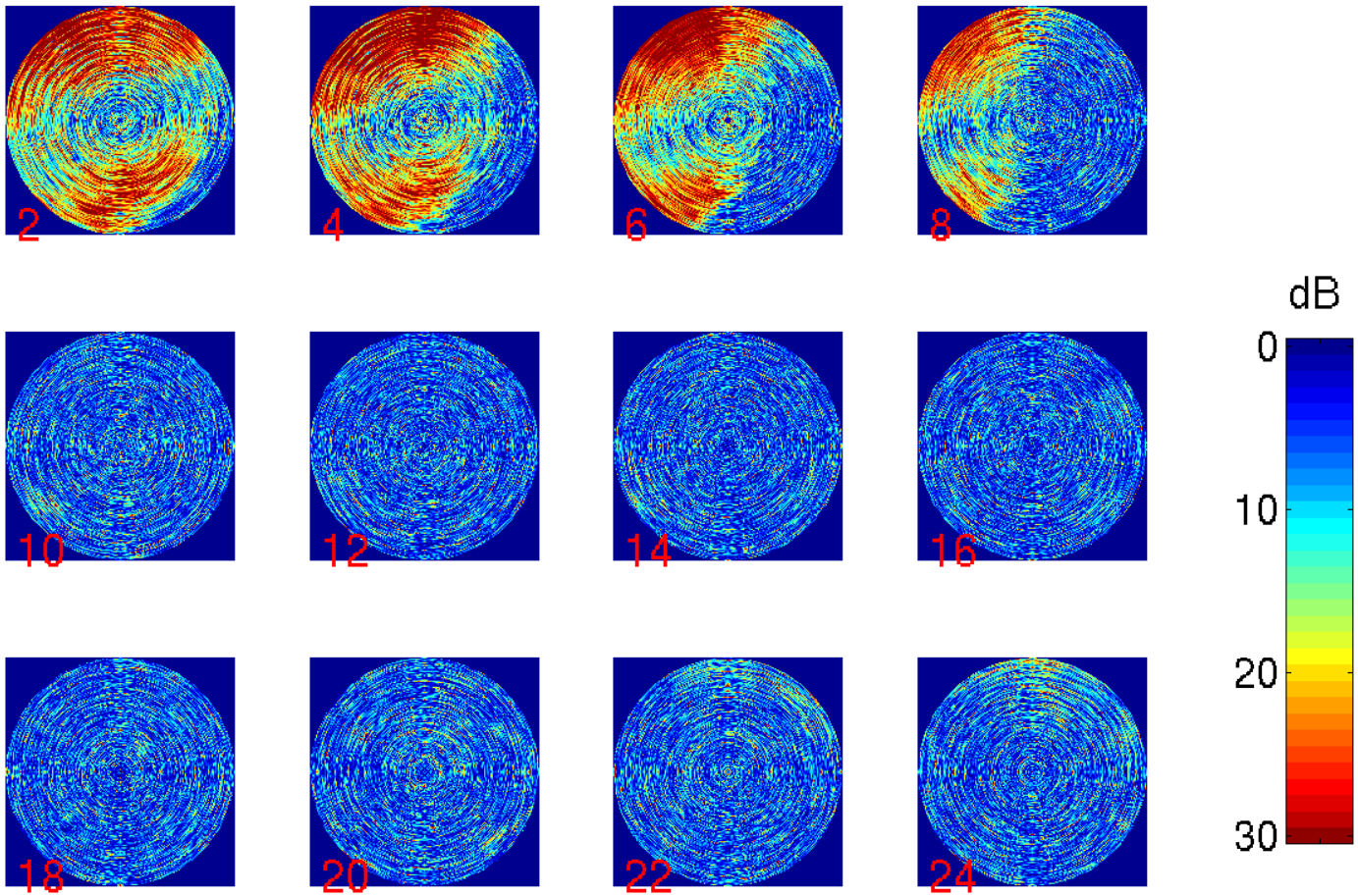
Transmission Loss (2 Profile)



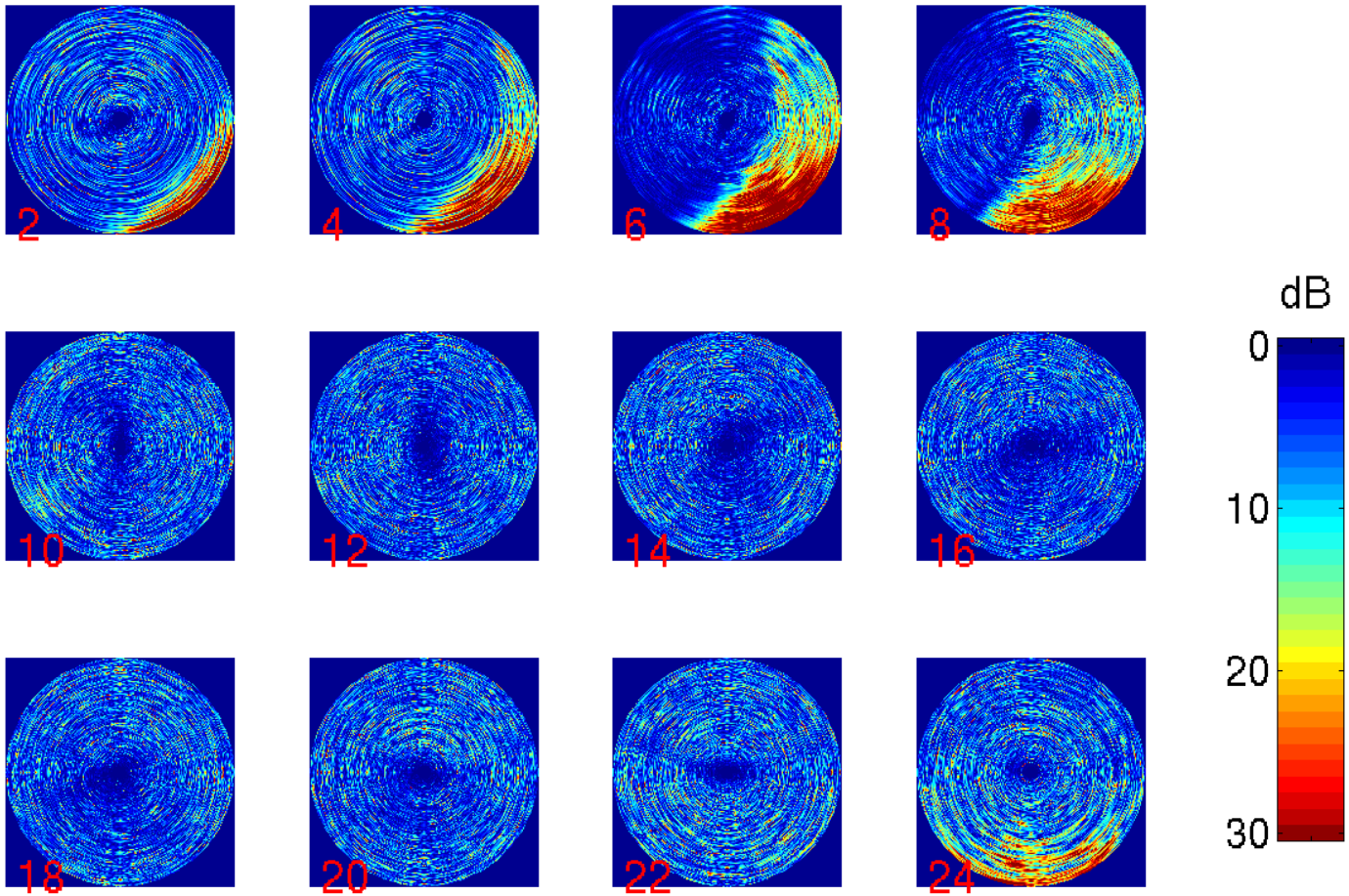
Difference (Real Ocean/Cold Water)



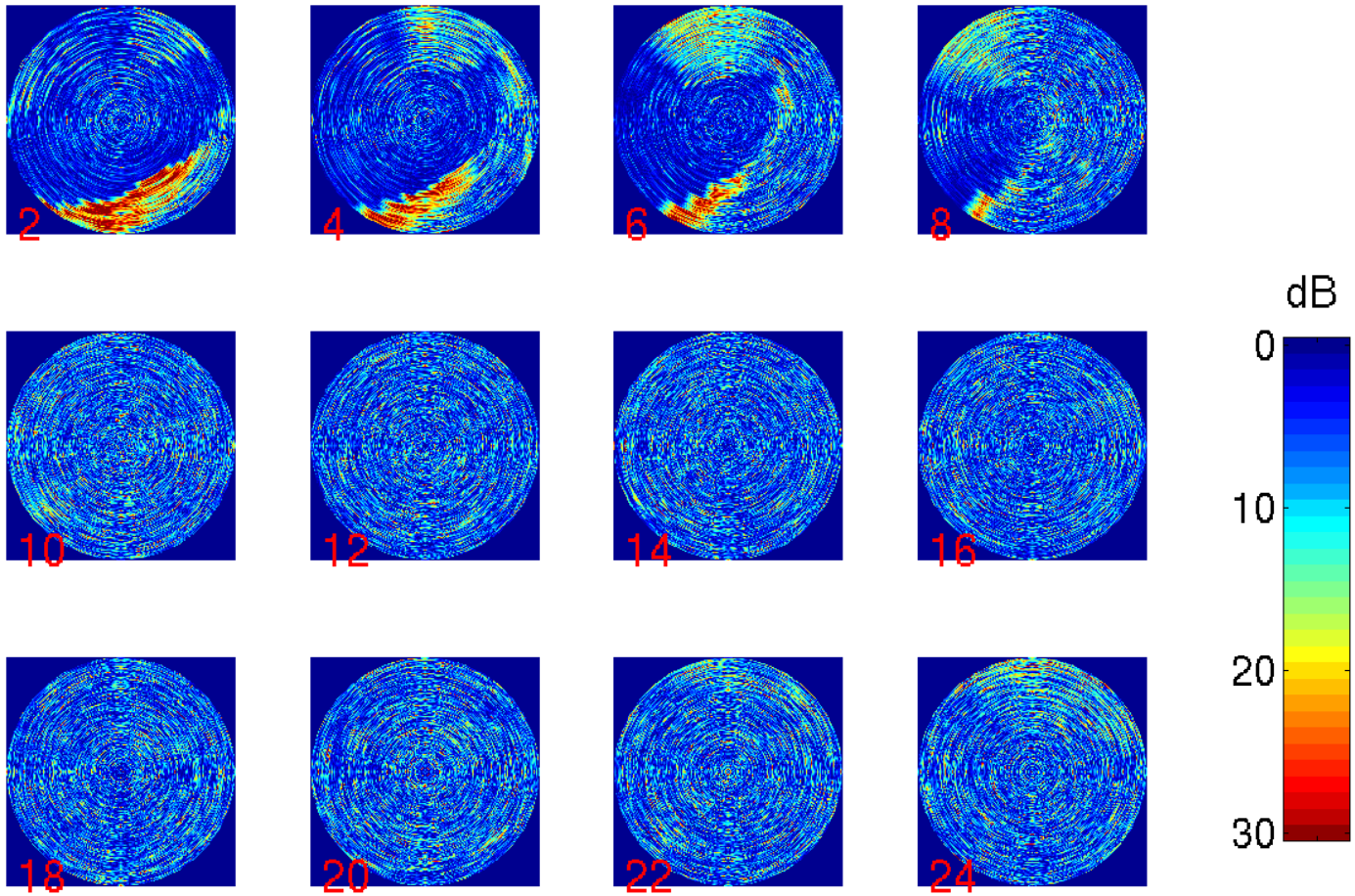
Difference (Real Ocean/Warm Water)



Difference (Real Ocean/RI Profile)



Difference (Real Ocean/2 Profile)



Minimum Detection Level

Sonar Equation

$$SE = SL - TL - RD - NL + AG$$

SE : Signal excess in dB

SL : Source level of target in dB//1uPa^2

TL : Transmission loss in dB (modeled as a variable in range)

RD : Recognition differential in dB (S/N at detection threshold)

NL : Ambient noise in dB//1uPa^2 /Hz

AG : Array gain in dB

Minimum Detection Level (MDL)

$$MDL(r, \theta) = TL + RD - AG + NF$$

$NF = 10*\log \{180*[N_B(\theta+\phi)+N_B(\theta-\phi)]/\sin\phi\}$

$N_B = 10^{NL/10}$, NL ~ 77 dB (omni noise level)

RD = 0 dB,

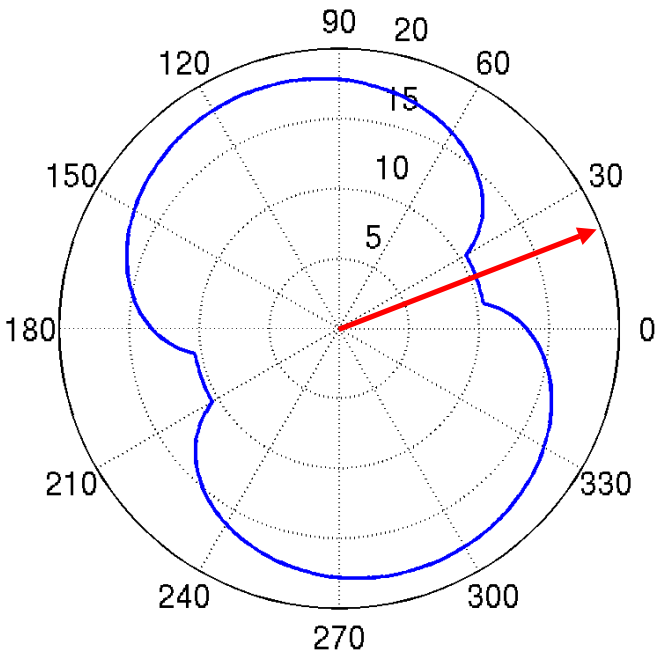
AG = 18 dB,

ϕ: ship heading

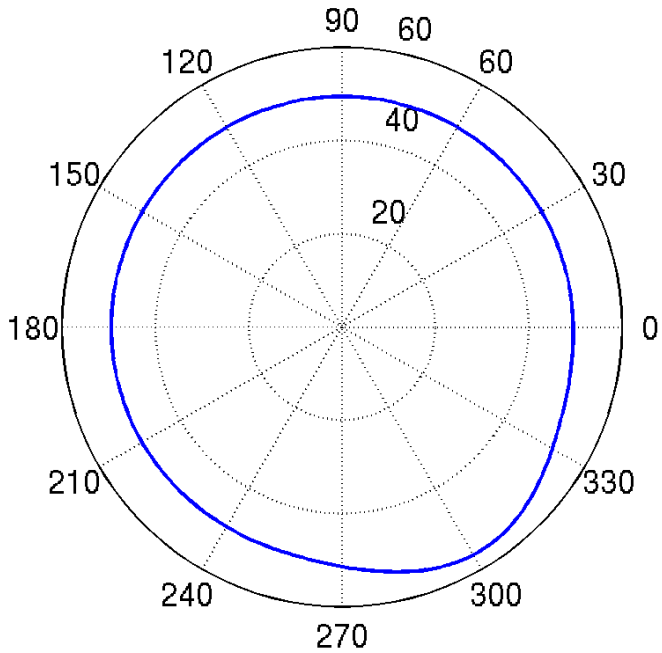
*MDL: A target located at the position whose source level is equal to or greater than MDL(r) has greater than a 50% probability of being detected (with a specified false alarm rate)

Array Gain & Ambient Noise

Array Gain (dB)



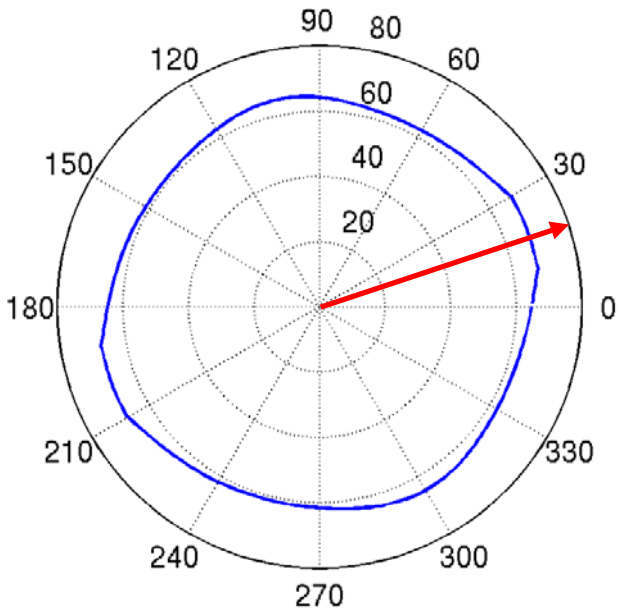
Ambient Noise (dB/1 deg)



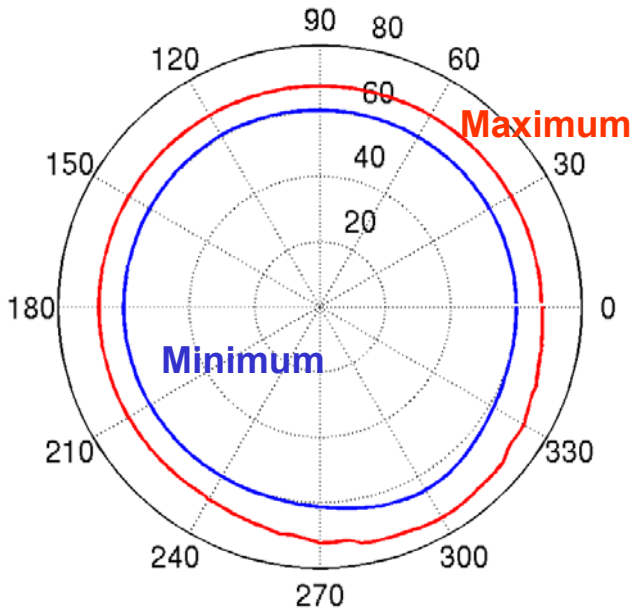
Omni noise level = 77 dB

Array Gain & Ambient Noise

Ship Heading (20°)



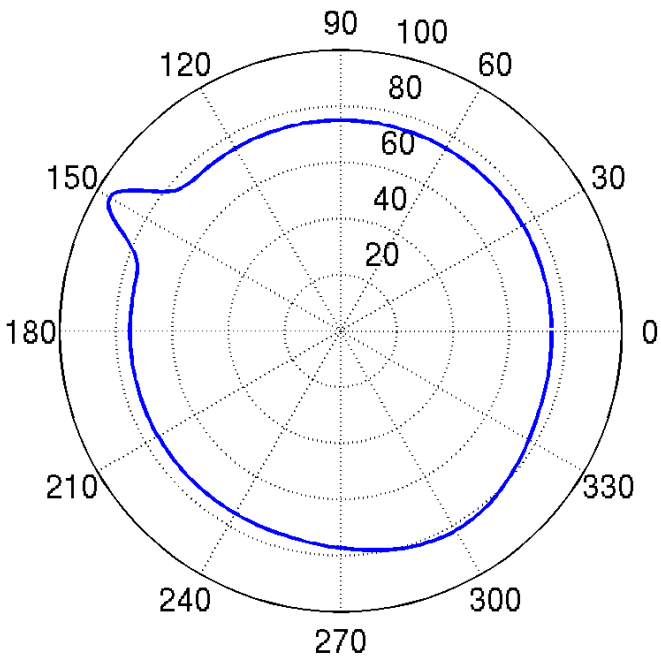
Min/Max



$$\text{NF-AG} = 10*\log\{180*[N_B(\theta+\phi)+N_B(\theta-\phi)]/\sin\phi\} - \text{AG}$$

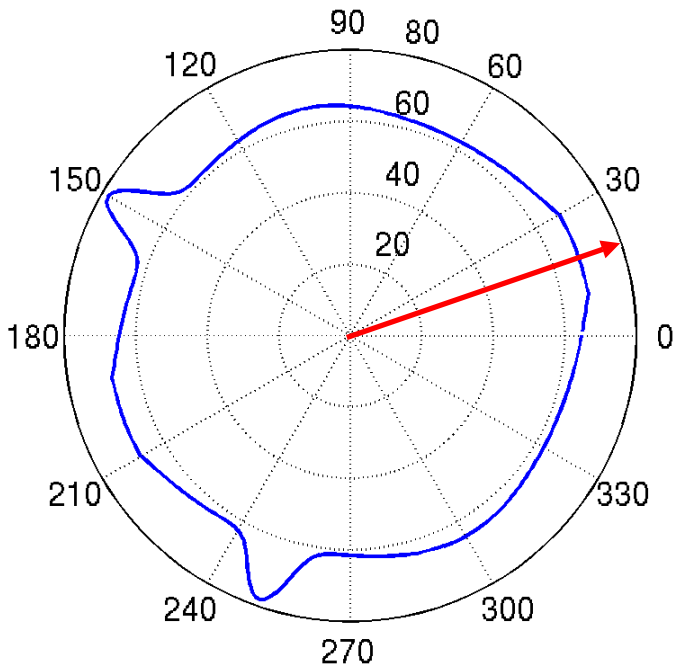
Discrete Ship Noise

Ambient Noise (dB/1 deg)



Omni noise level = 80 dB

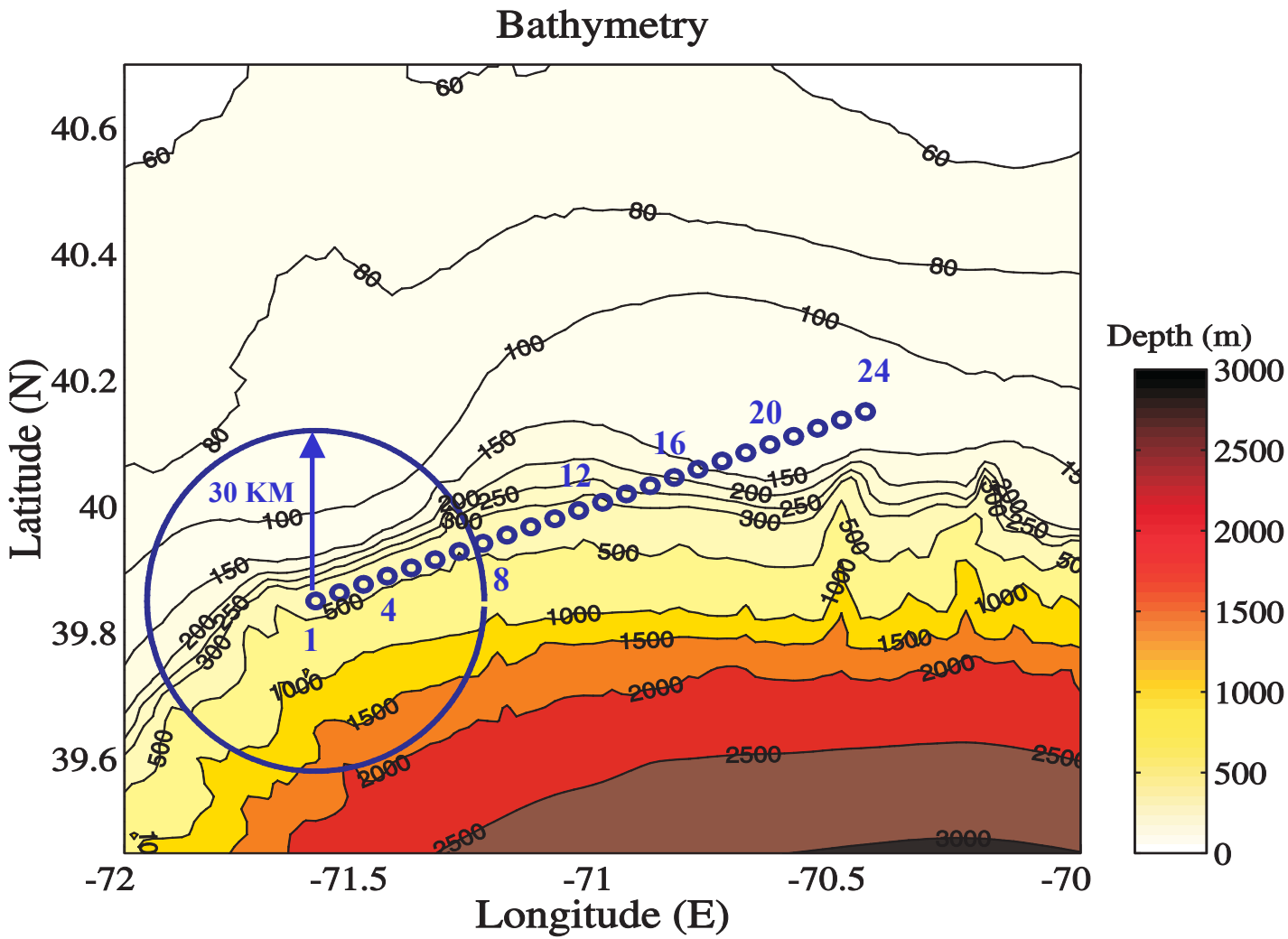
NL - AG (dB)



MDL along the Track

- Distant Shipping Traffics
- Discrete/Distant Shipping Traffics

Bathymetry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30 KM
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Depth (m)
3000
2500
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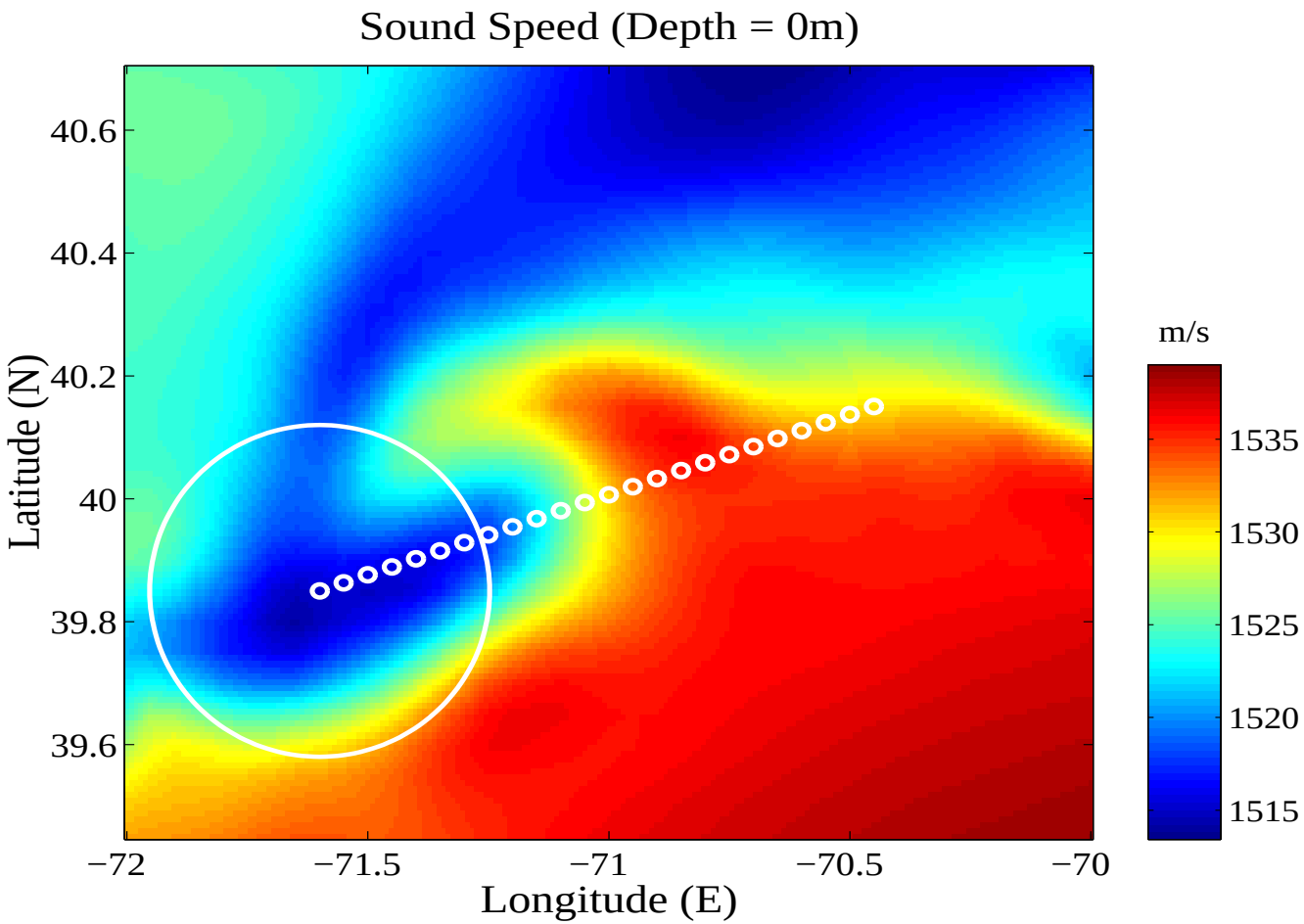
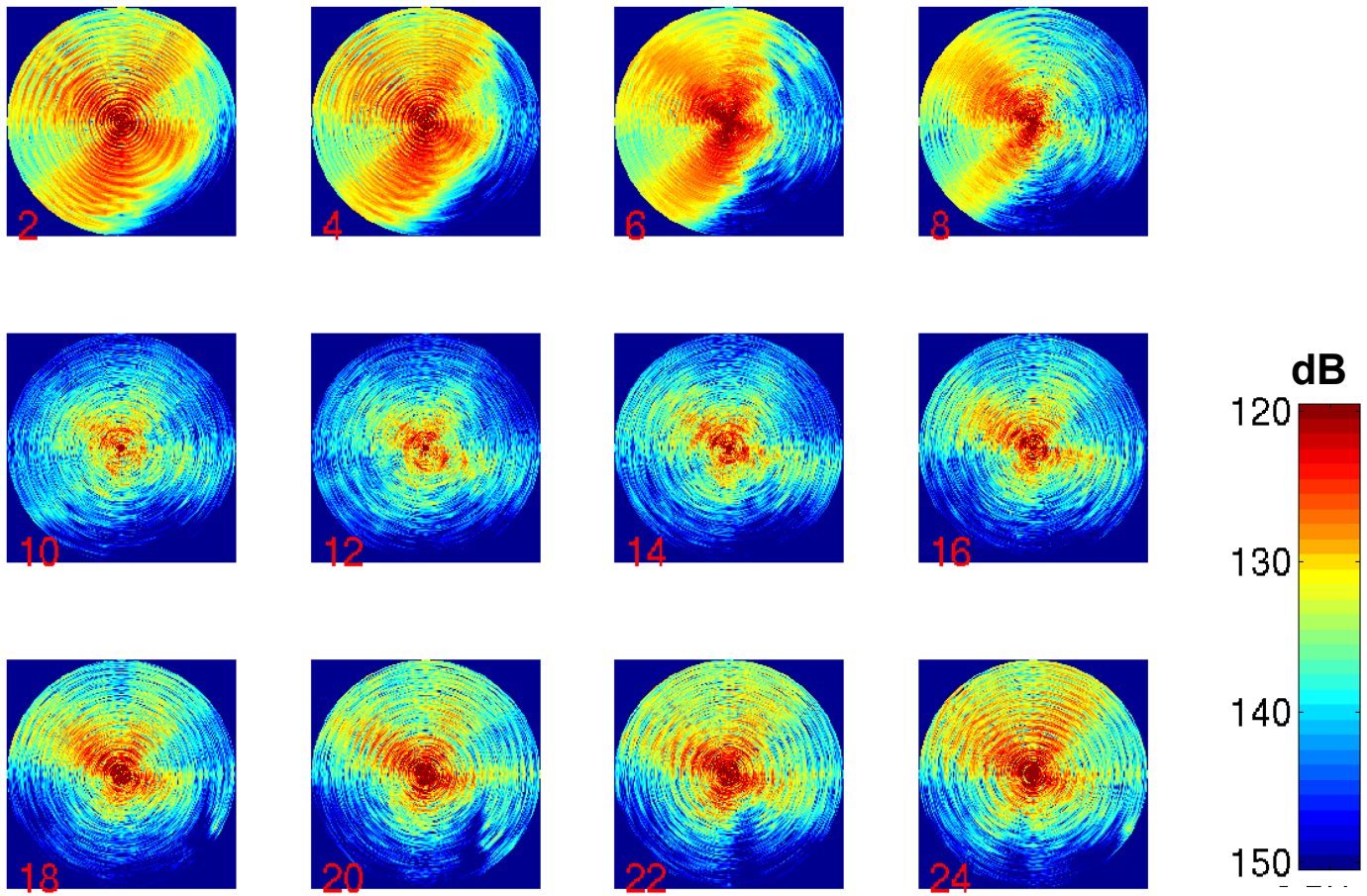
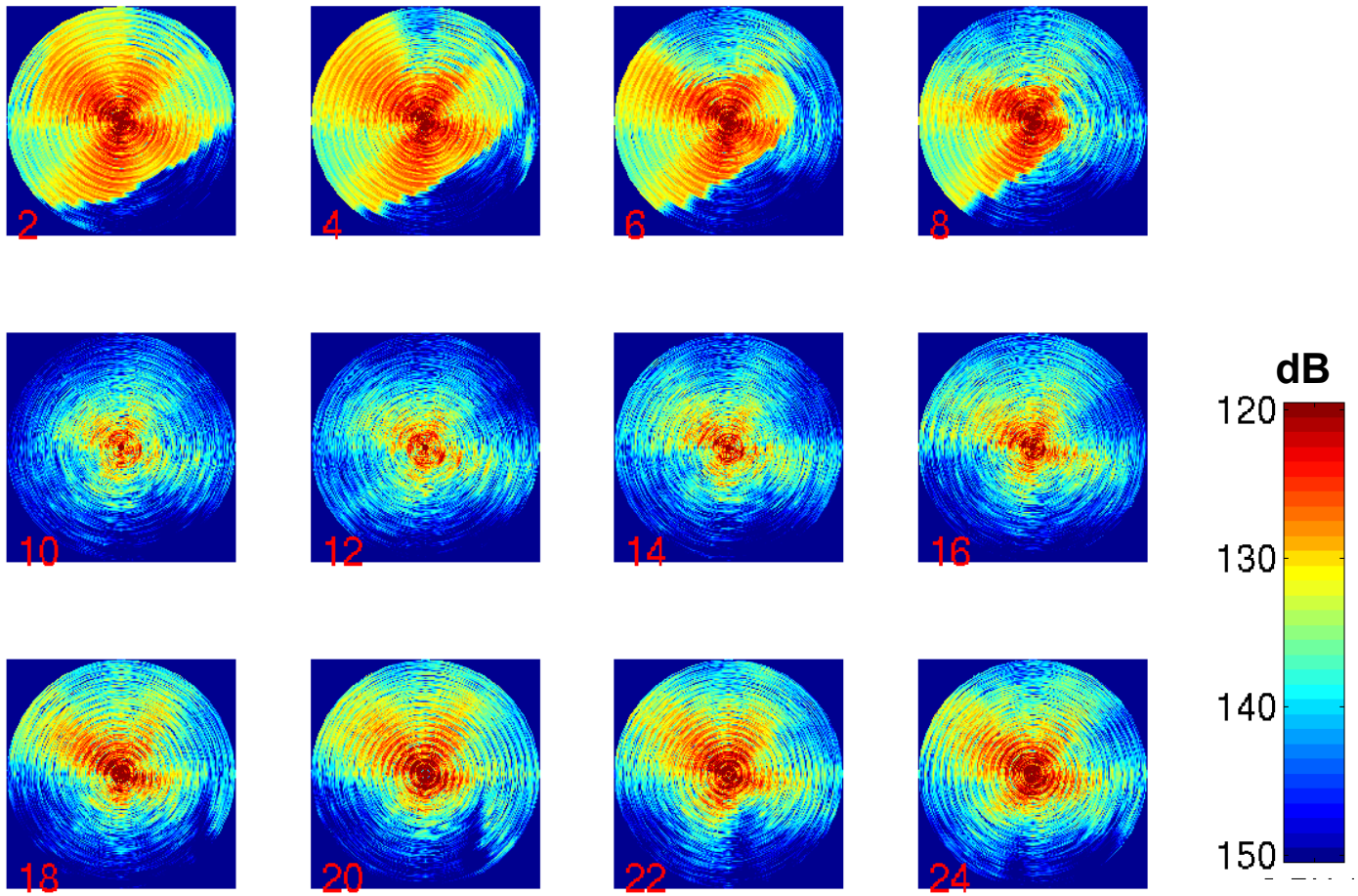
Surface Sound Speed



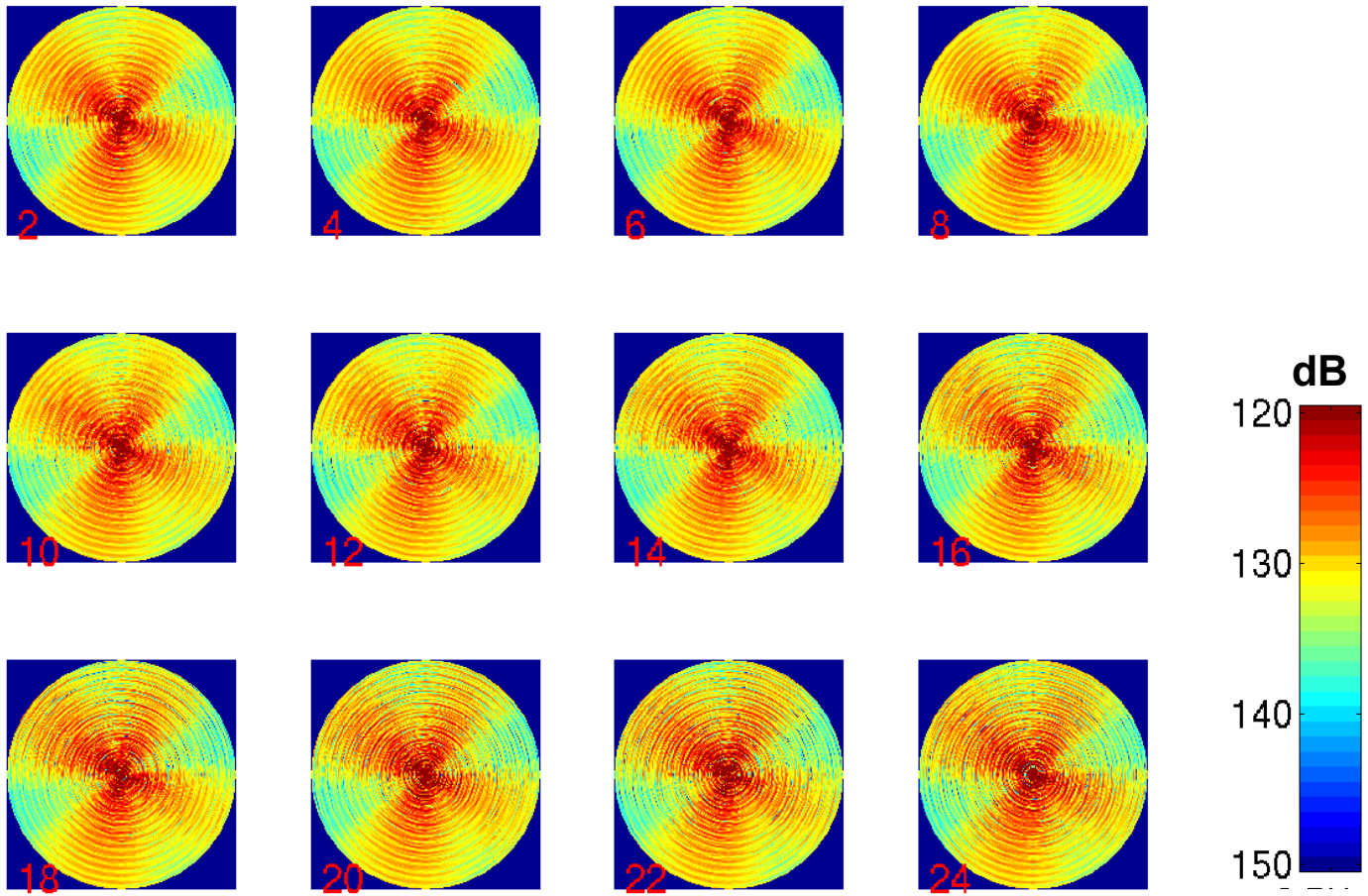
MDL (Real Ocean)



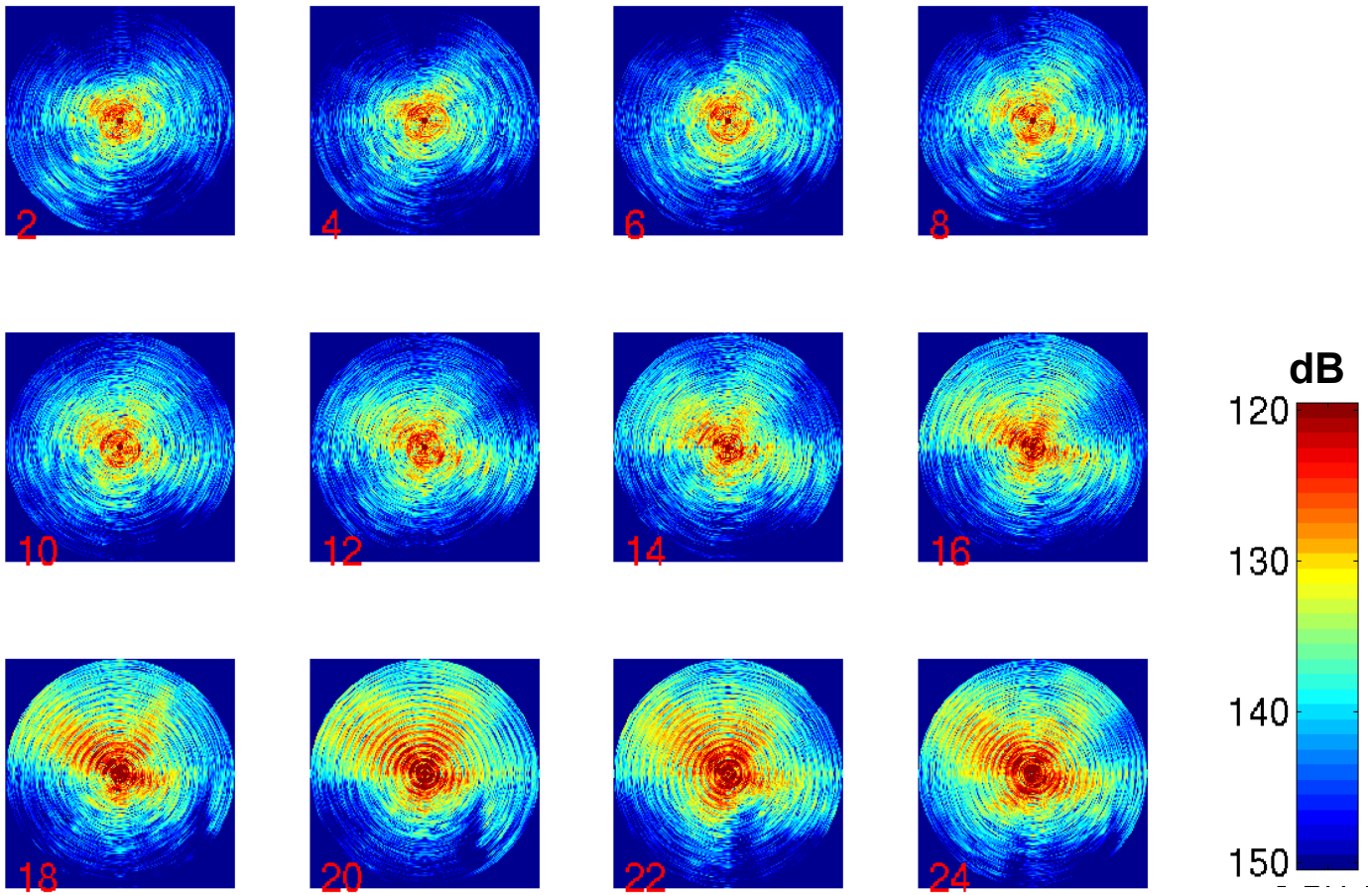
MDL (2 Profile)



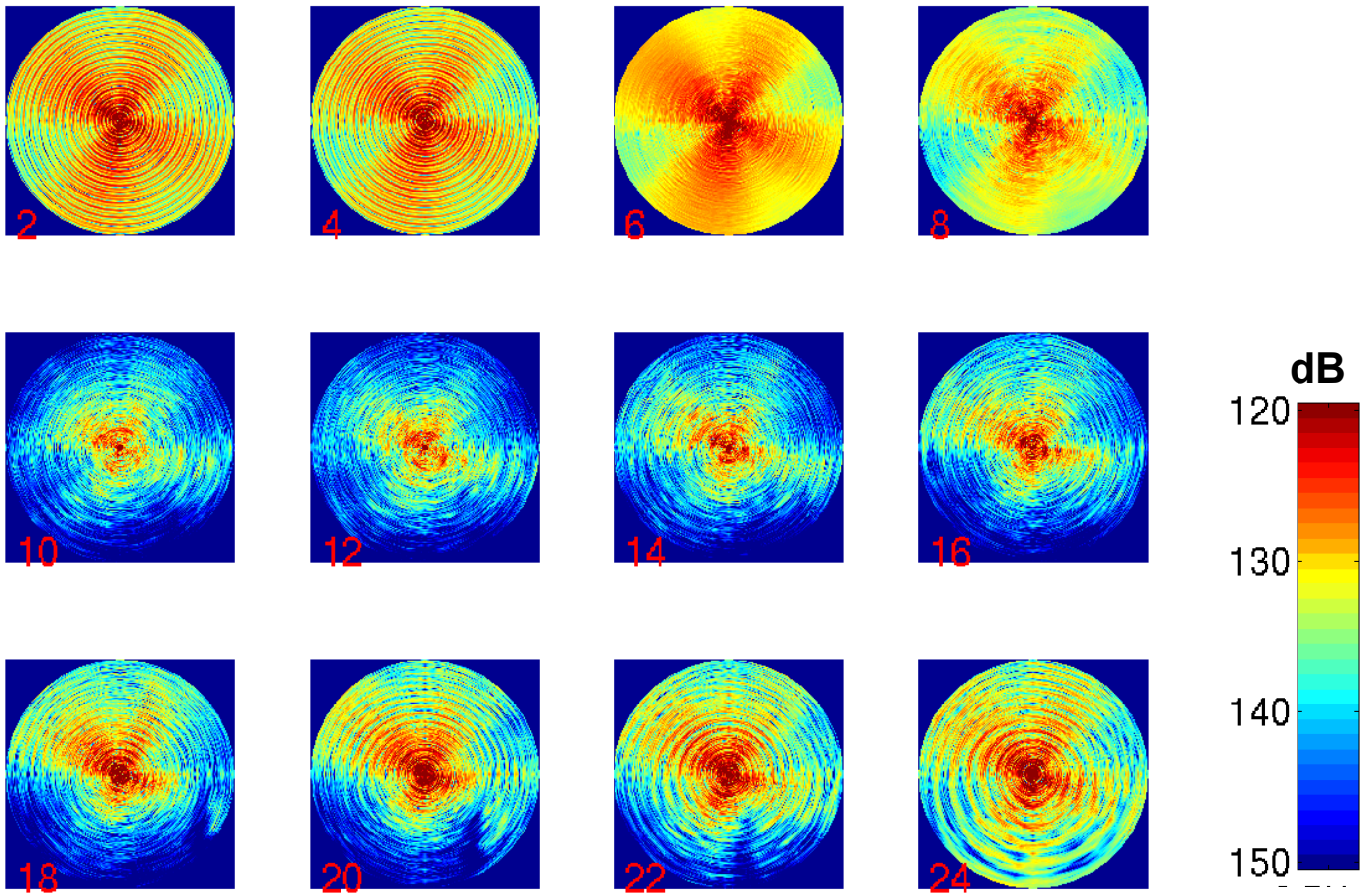
MDL (Cold Water)



MDL (Warm Water)

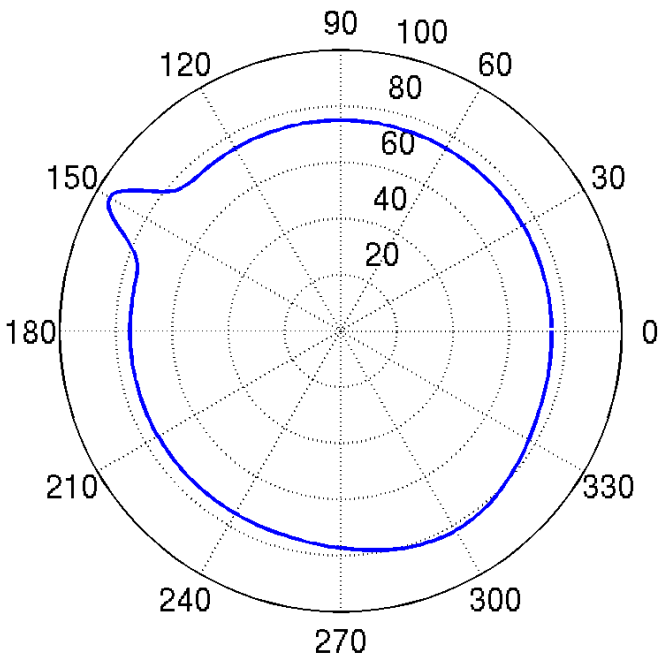


MDL (RI Profile)



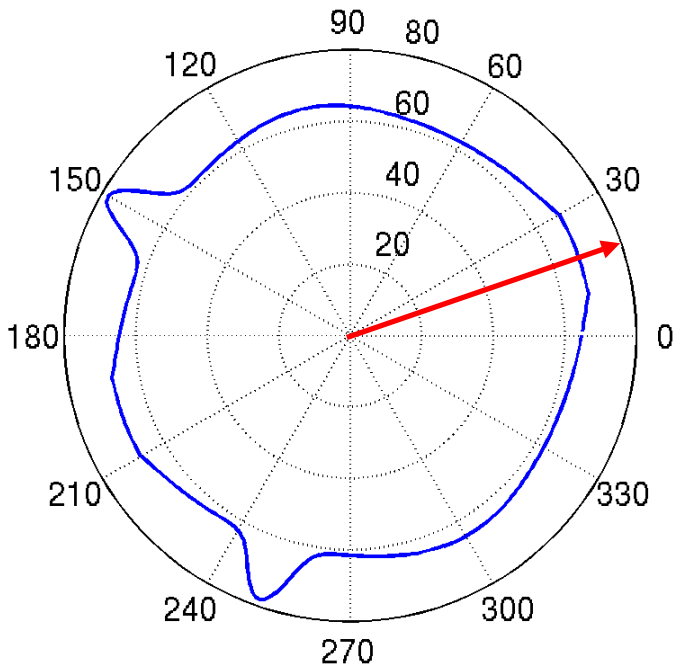
Discrete Ship Noise

Ambient Noise (dB/1 deg)

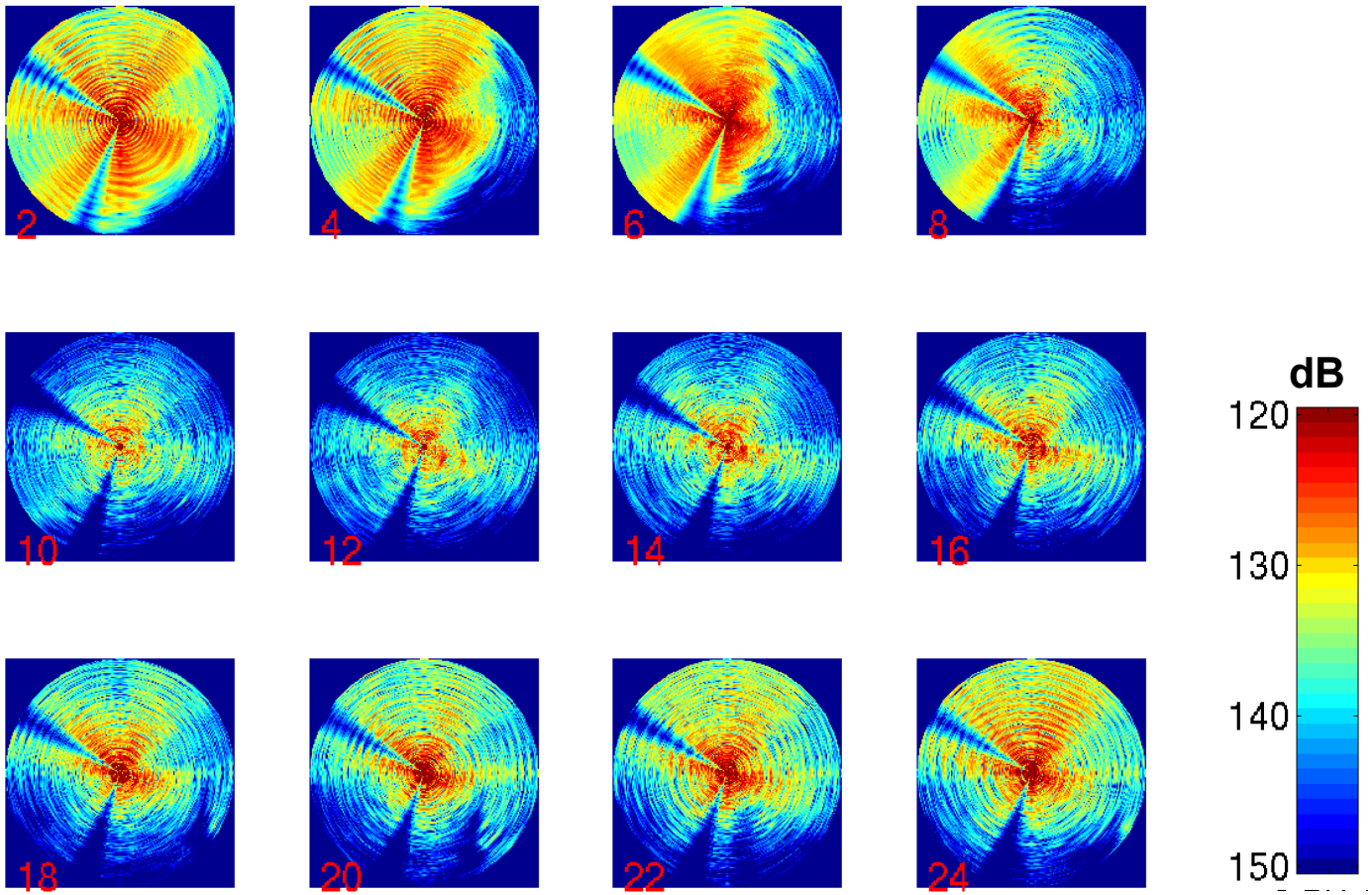


Omni noise level = 80 dB

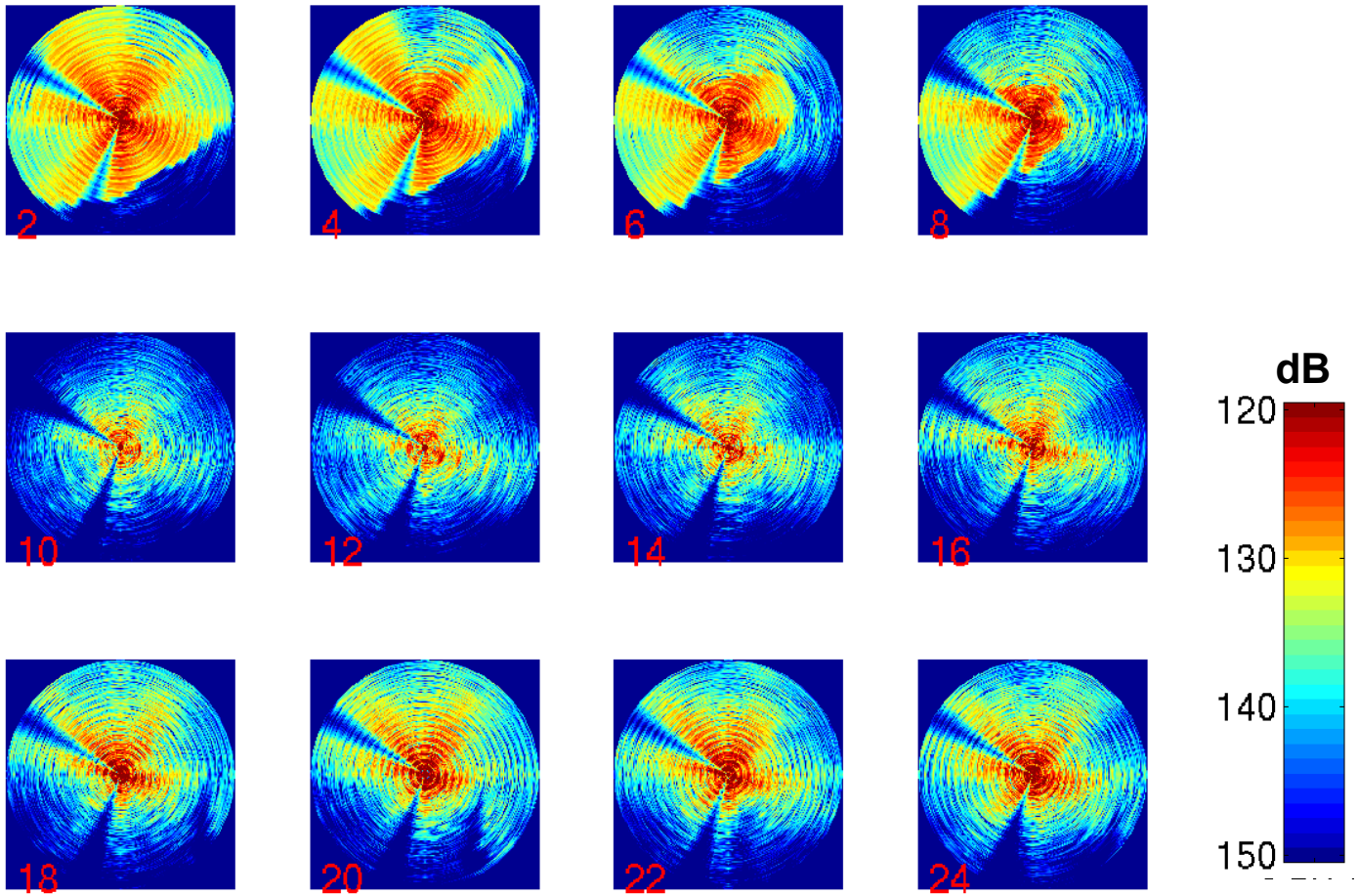
NL - AG (dB)



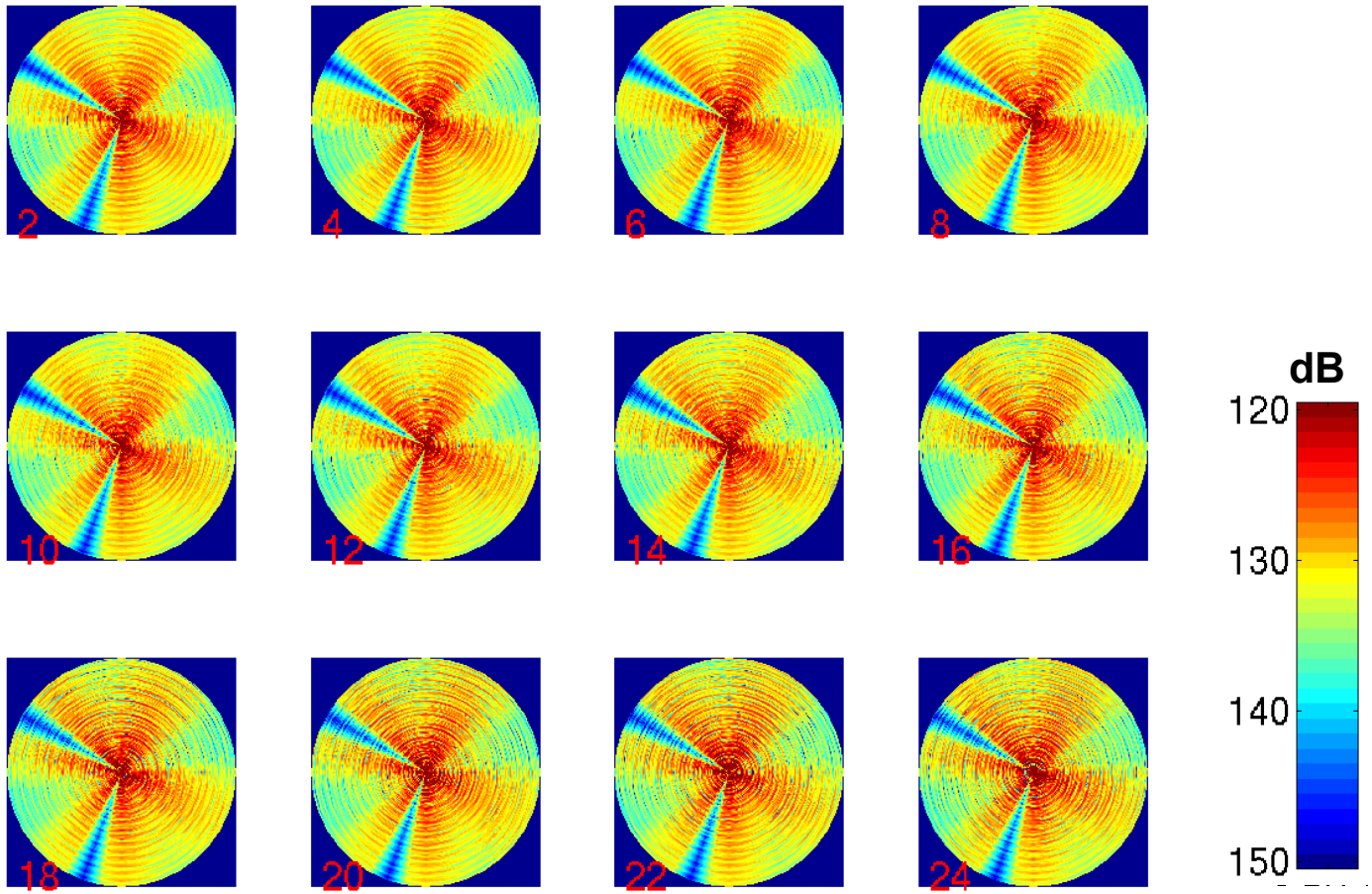
MDL (Real Ocean)



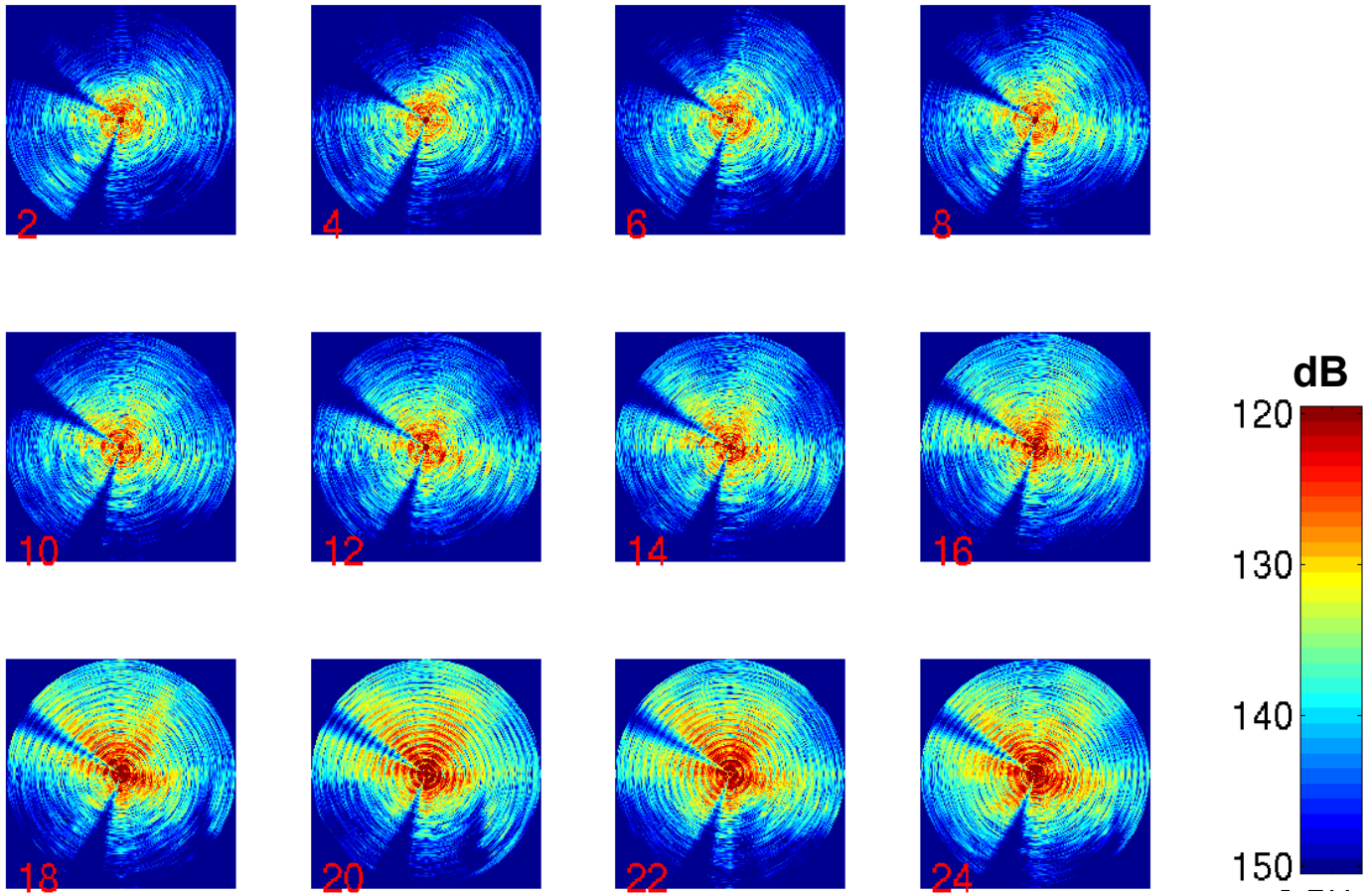
MDL (2 Profile)



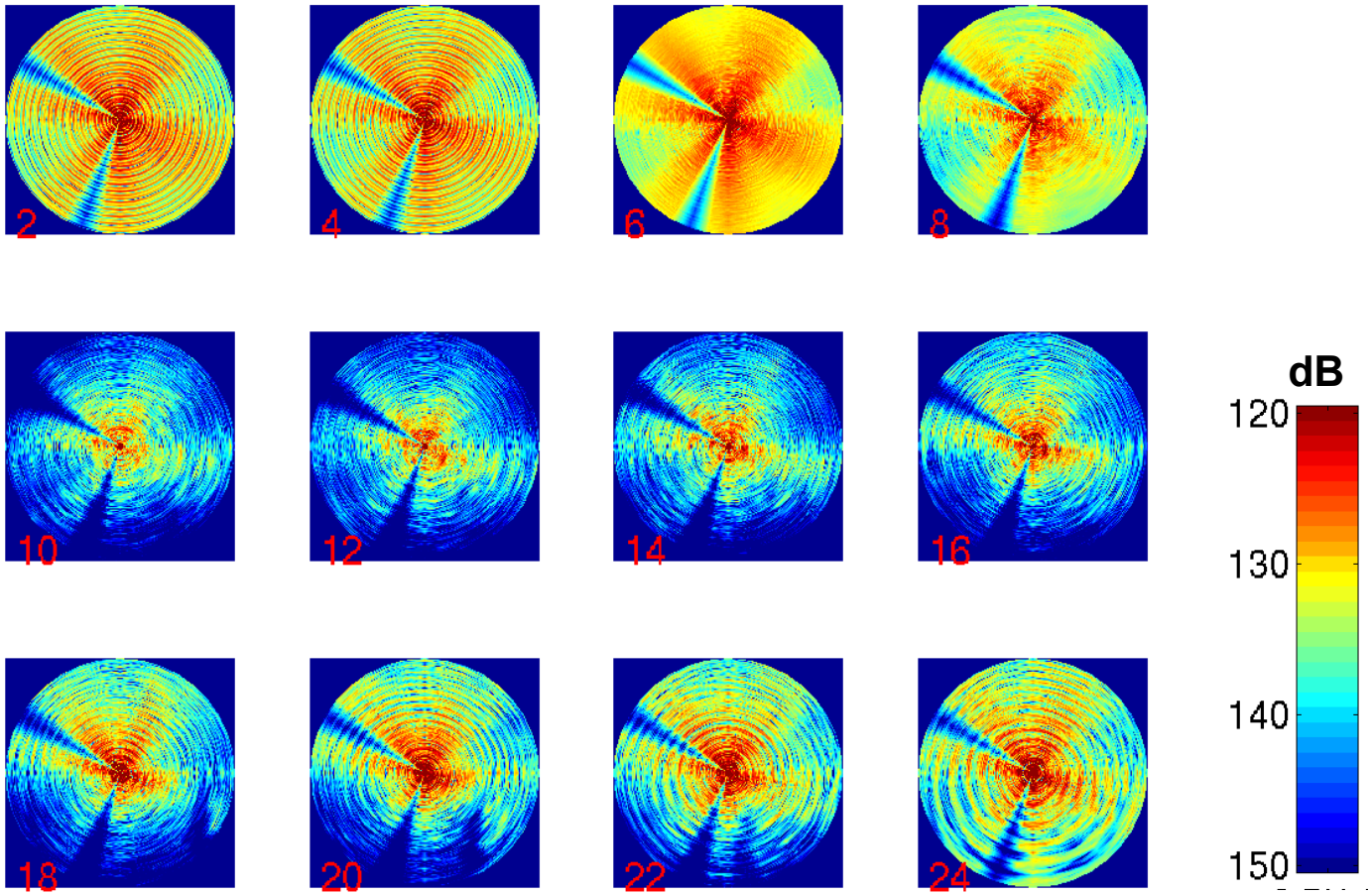
MDL (Cold Water)



MDL (Warm Water)



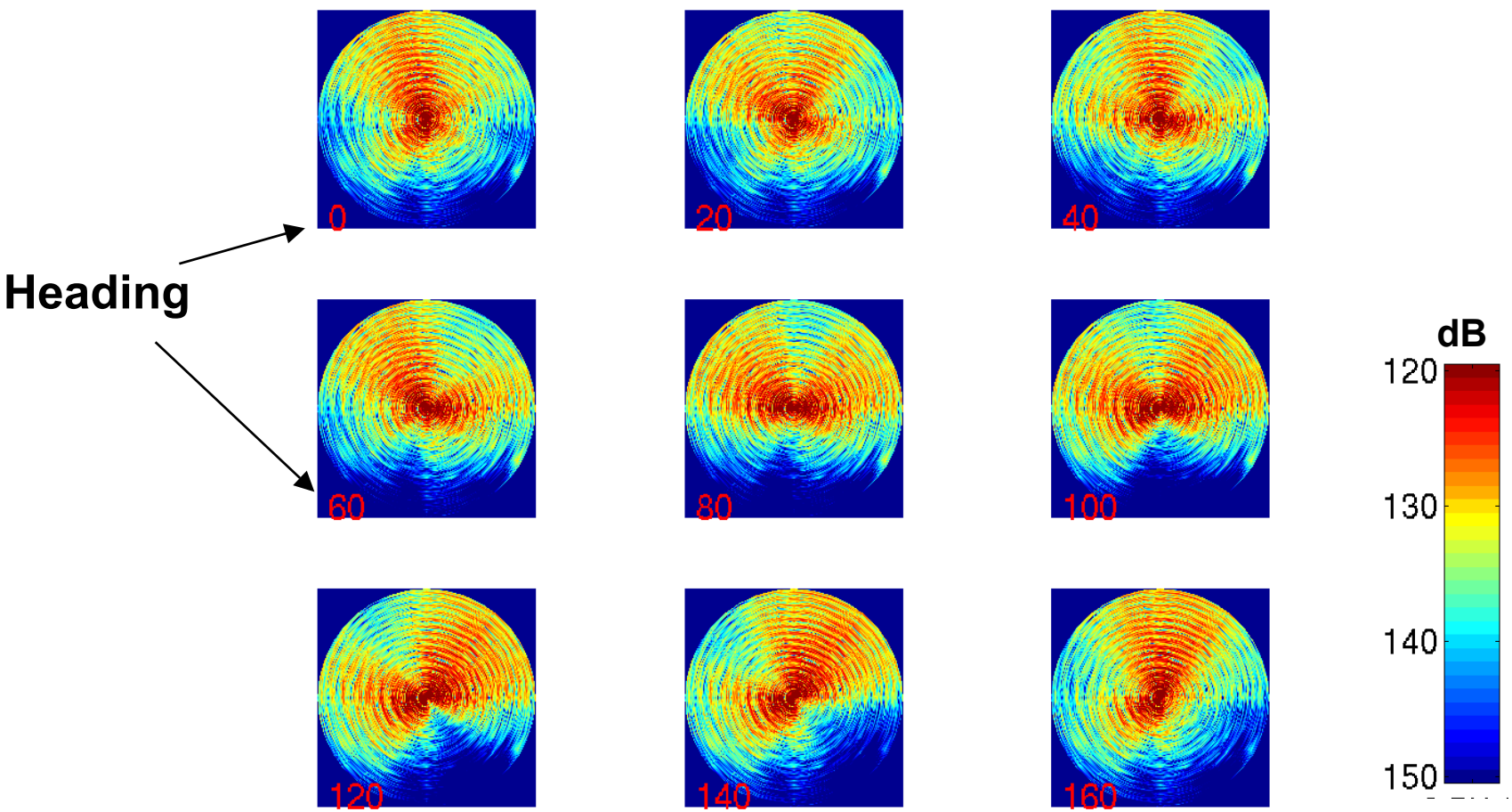
MDL (RI Profile)



MDL with Ship Heading

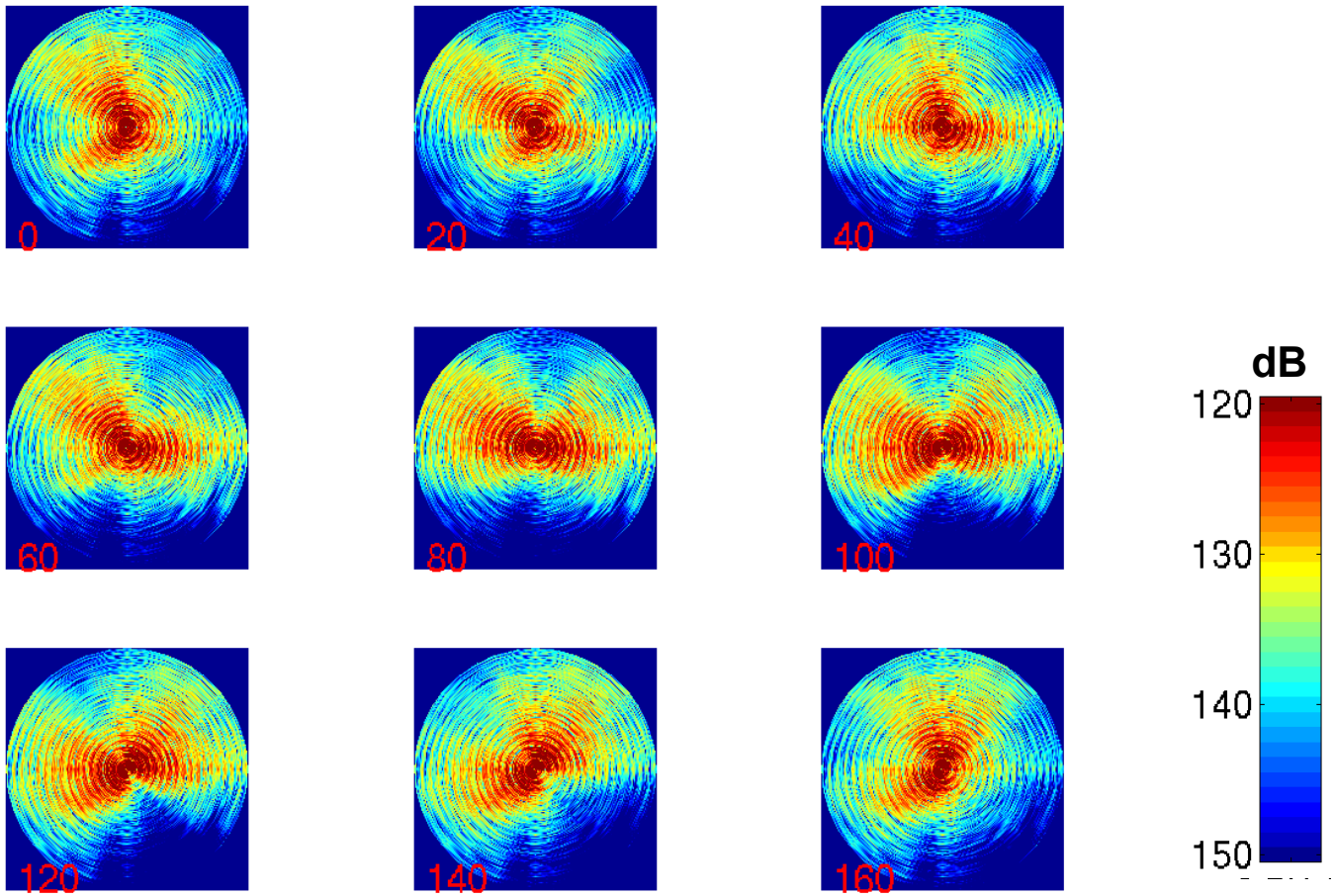
- Distant Shipping Traffics
- Discrete/Distant Shipping Traffics

MDL (Real Ocean)

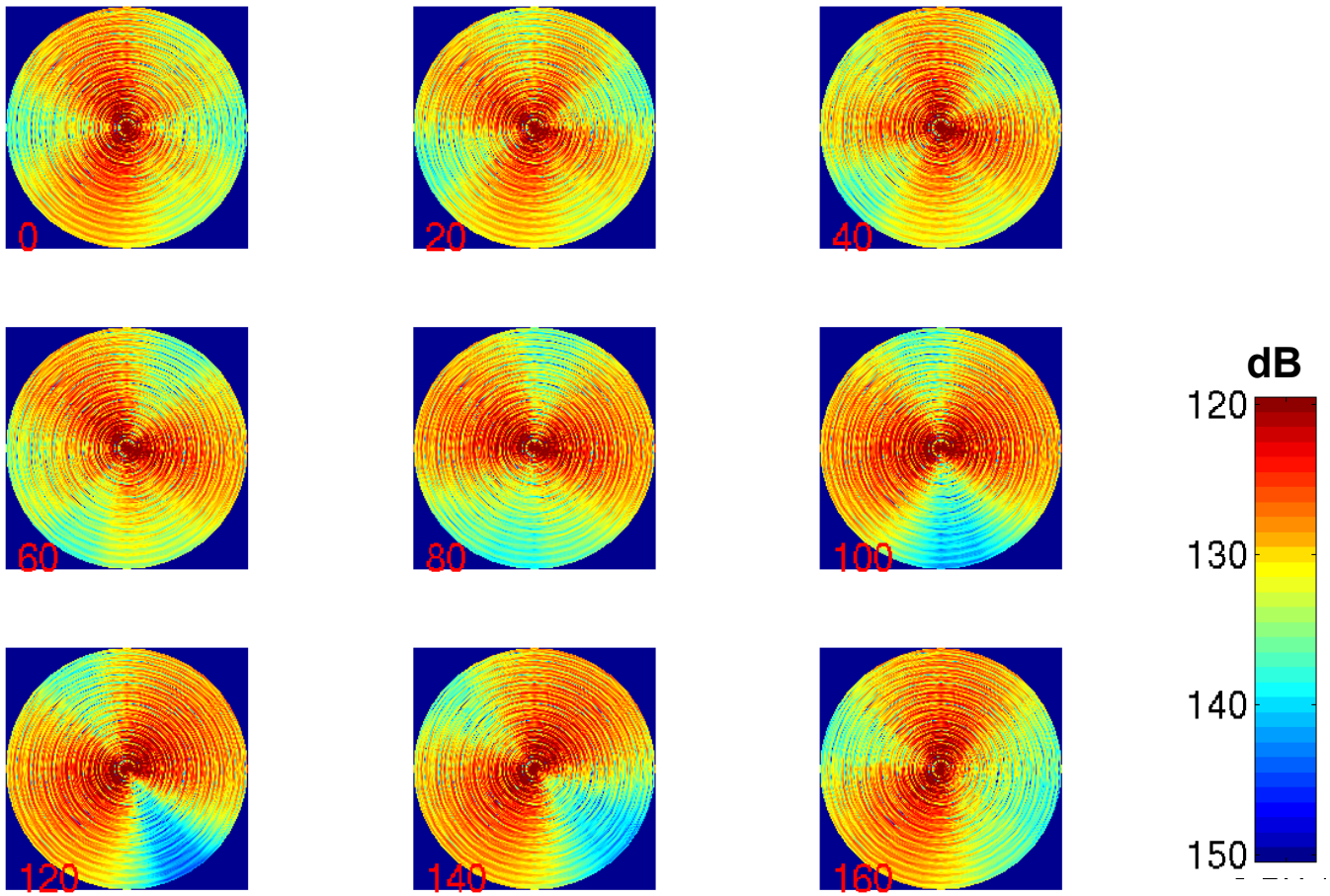


Direction :
Counter-Clockwise from East

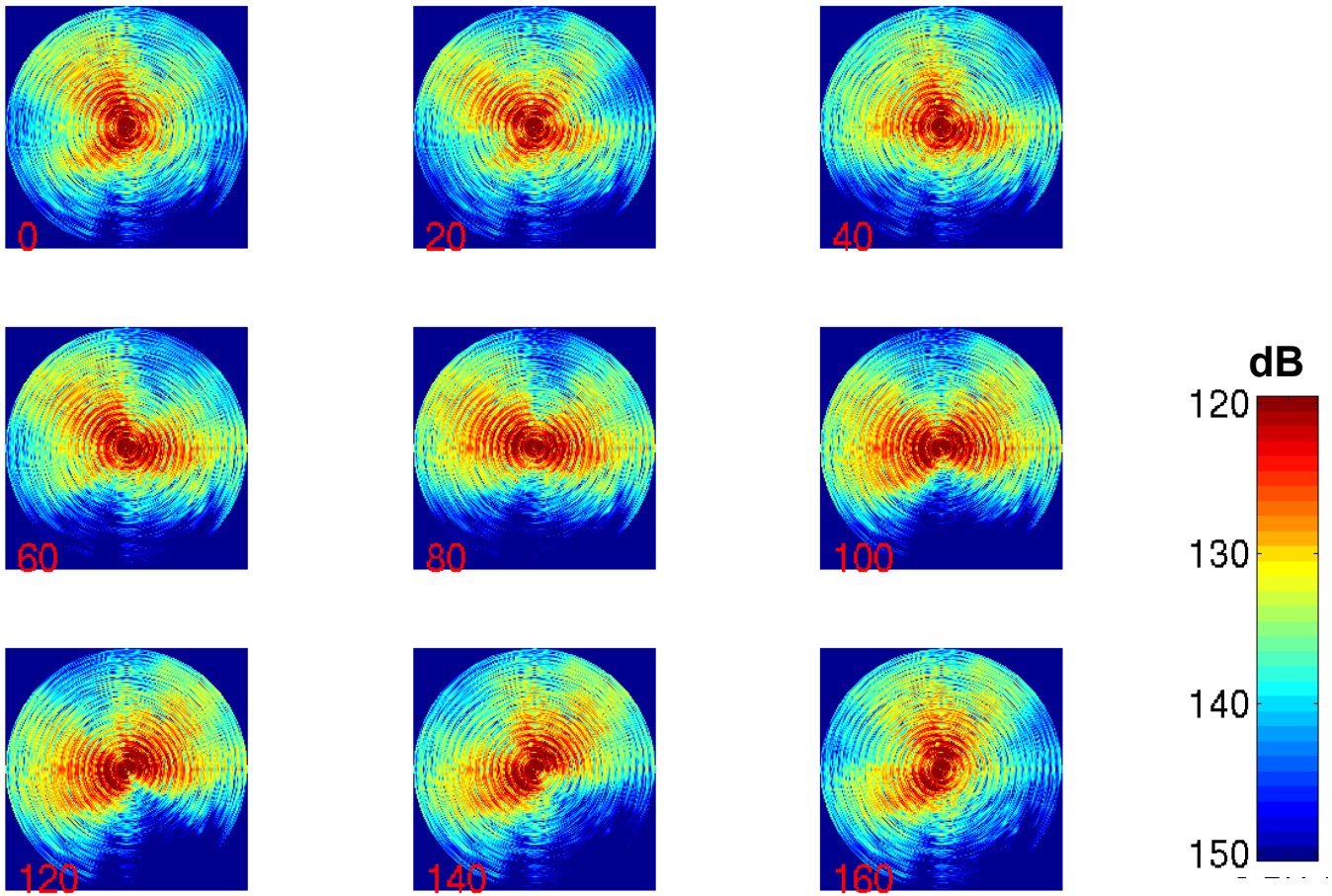
MDL (2-Profile)



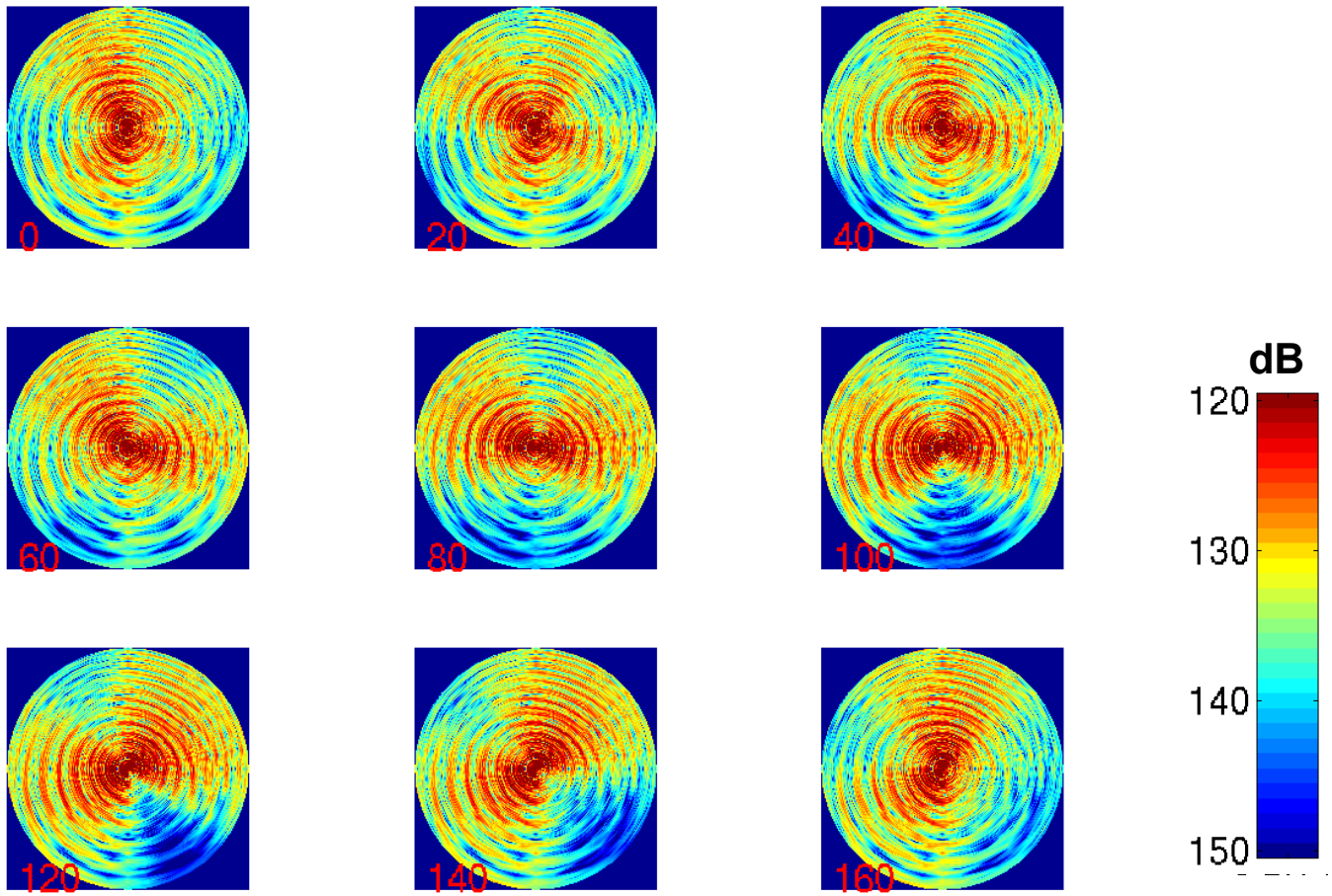
MDL (Cold Water)



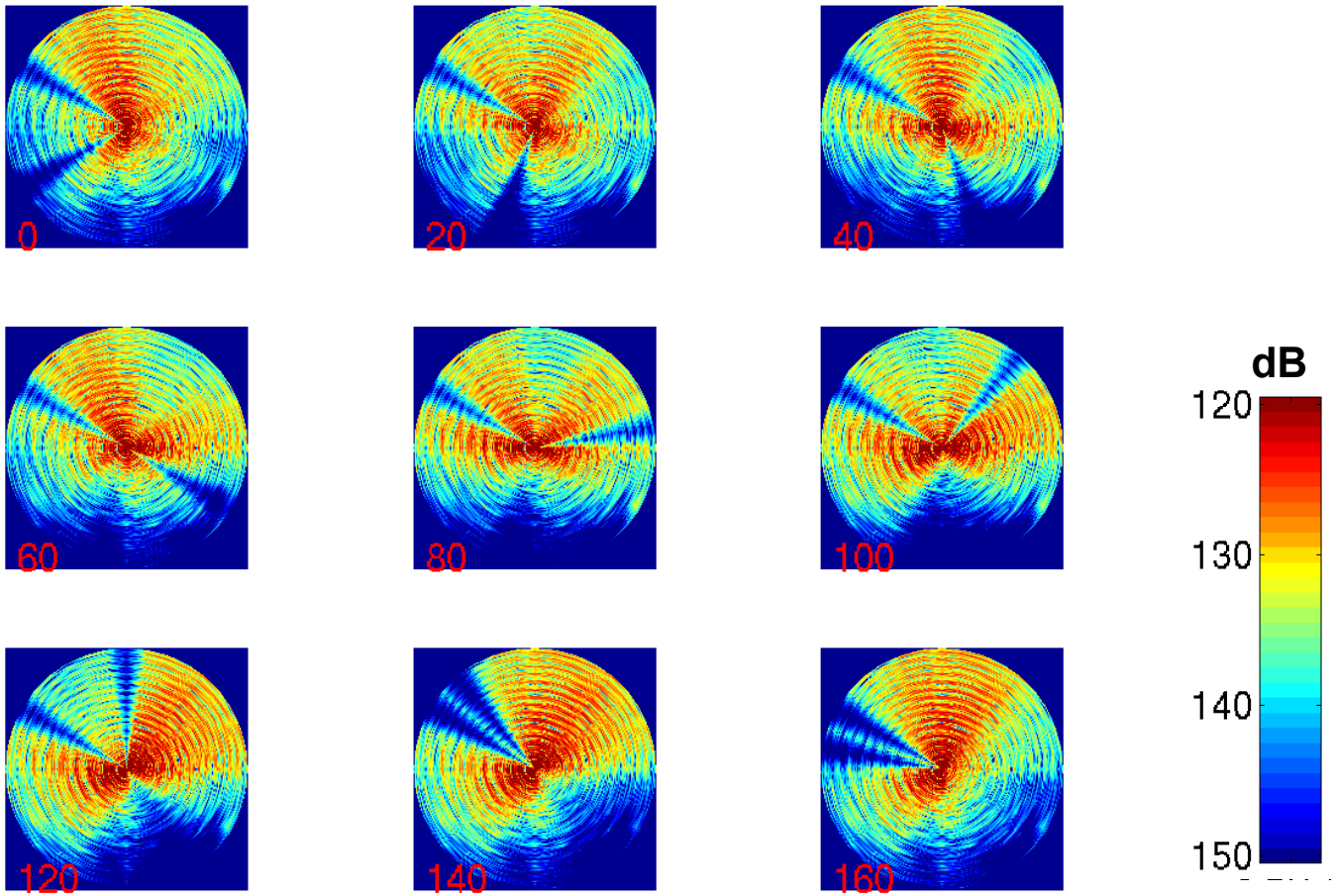
MDL (Warm Water)



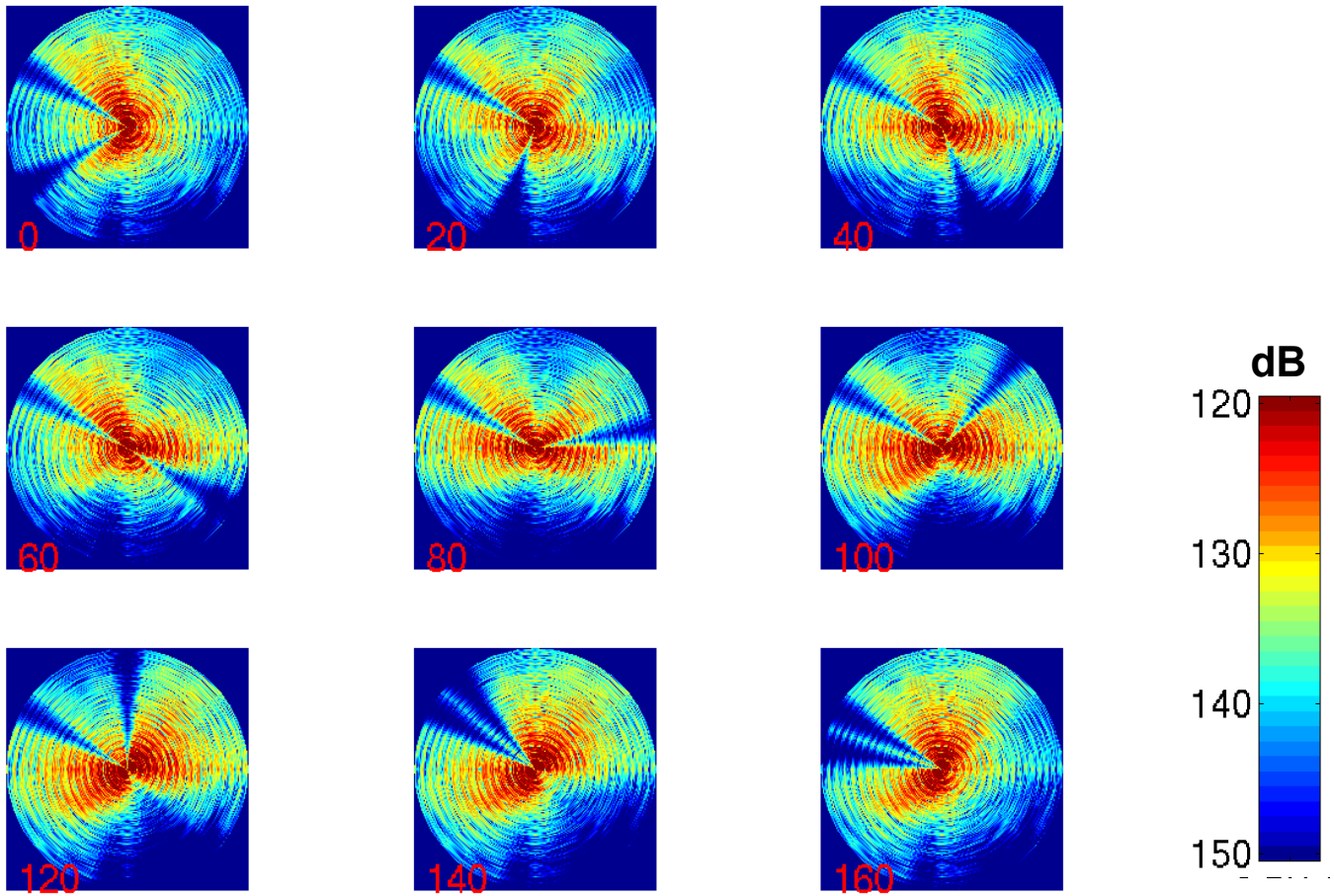
MDL (RI Profile)



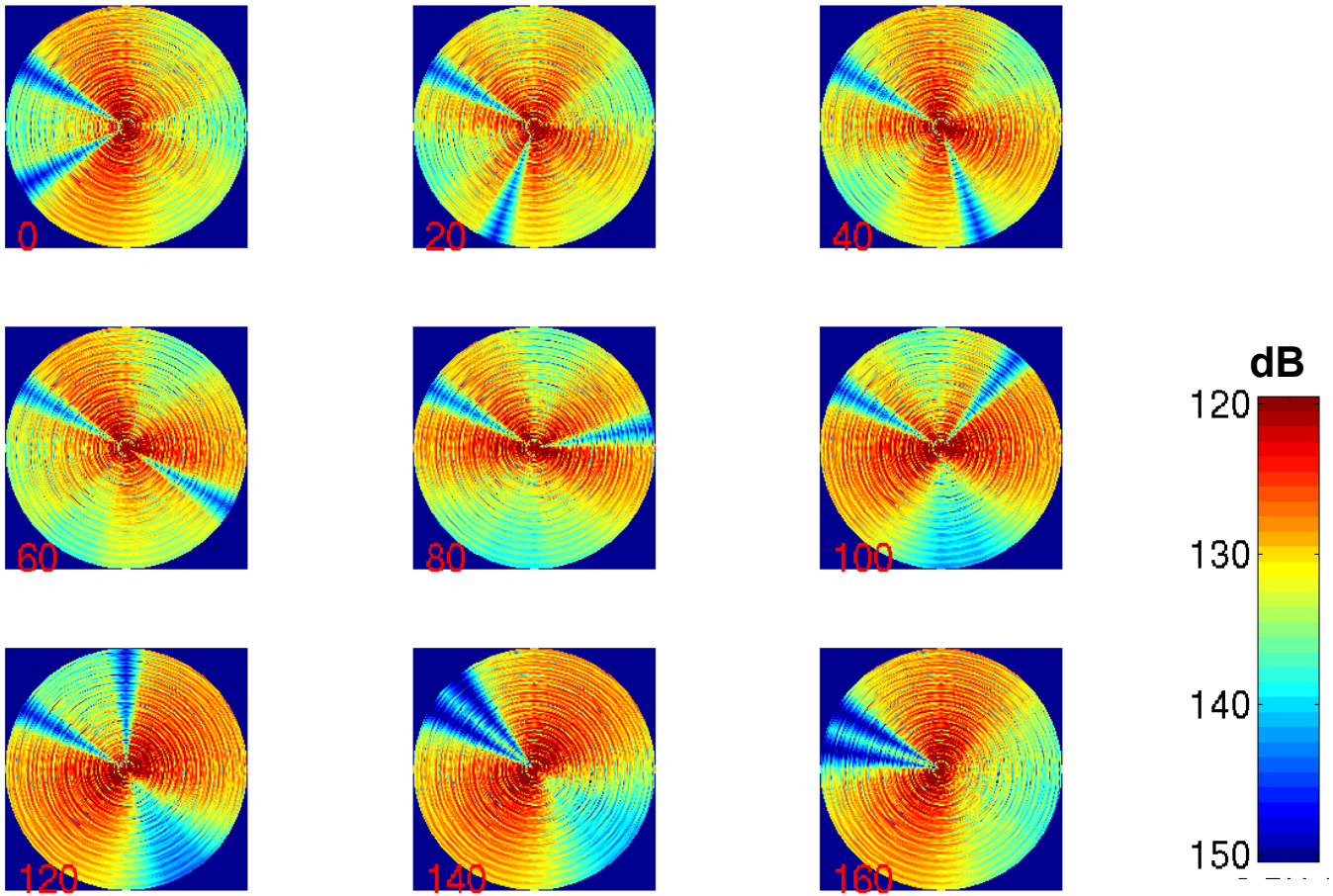
MDL (Real Ocean)



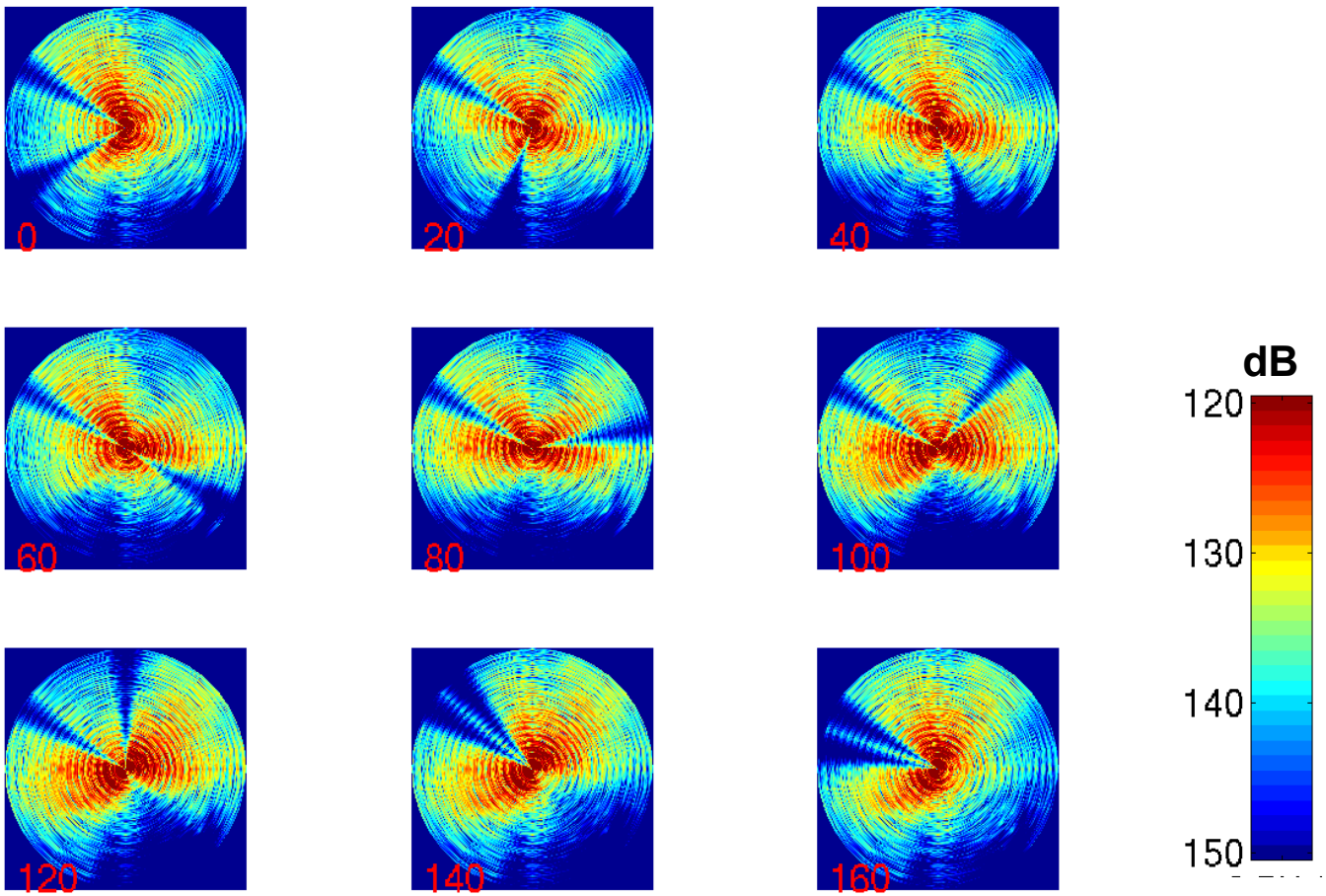
MDL (2 Profile)



MDL (Cold Water)



MDL (Warm Water)



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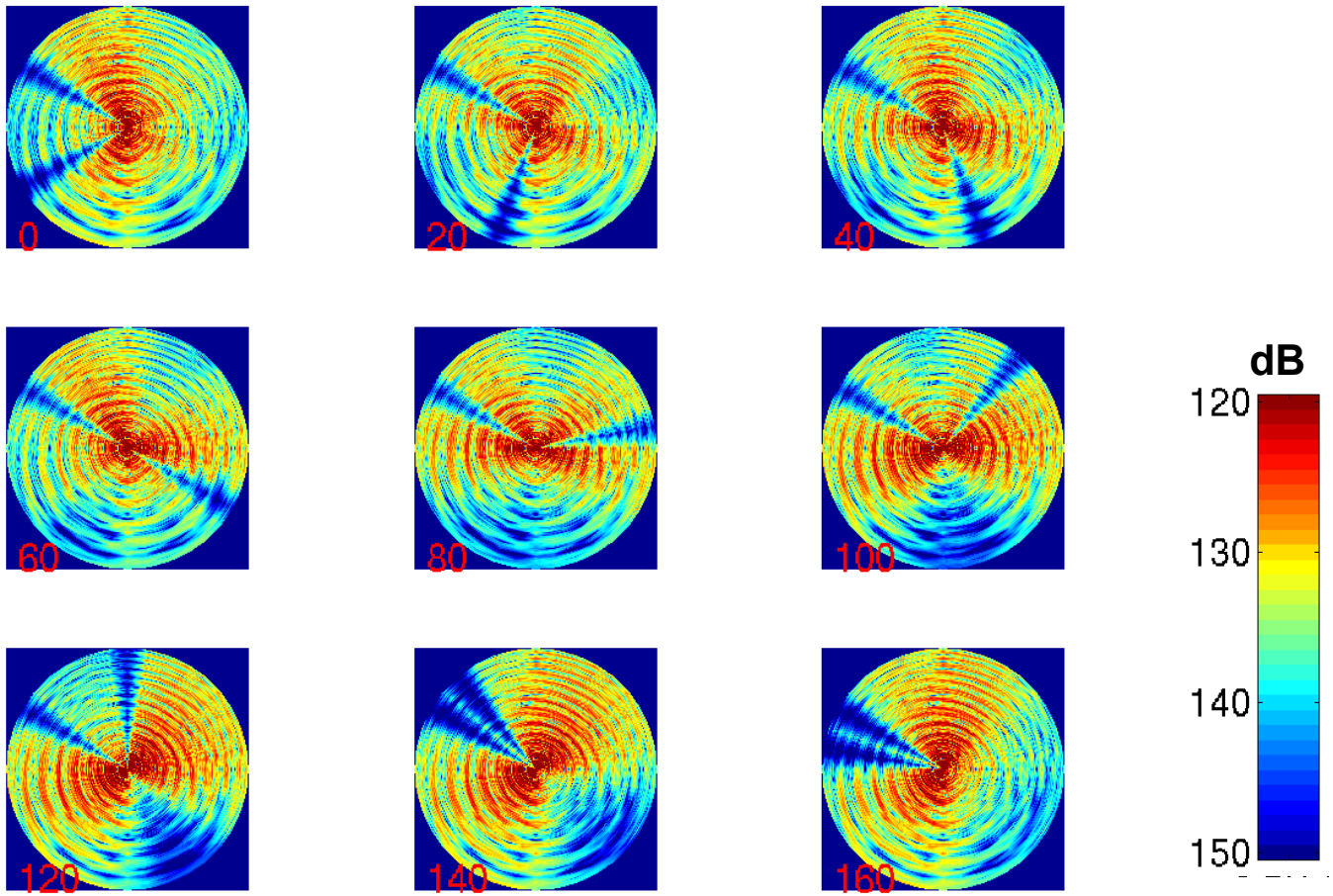

Conclusions

- Oceanography and Bathymetry significantly impact Performance Prediction.
  Other factors: Noise Structure, System Parameters
- Single Profiles lead to poor predictors in complex regions.
- Predictions enhanced over single profiles by including oceanographic features and (reduced number of) profiles.
- Uncertainty in sonar performance prediction can be propagated through a performance prediction model.

Brief narrative of

"Area Wide System Performance from environmental and acoustic
fields"
by W. A. Kuperman

The performance prediction of a generic towed array in a complex littoral ocean environment is studied by simulation.

Slides 3-14

The tow track through the ocean environment is displayed. The ocean environments were obtained from the Harvard group. A full three-dimensional ocean generated by the Harvard model is denoted for these simulations as the "real ocean." The bottom bathymetry is that of the Primer area. In the simulation, two constant oceanographic environments are also use, (cold and warm) as well as a feature model with both the cold and warm water profiles separated by a gulf stream "feature" as supplied by the Harvard group.

Slides 15-26.

Transmission loss results are provided for the various environments for particular source receiver depths and for areas centered around the moving towed array's instantaneous
positions.

Slides 27-35

The basic performance prediction is presented in terms of minimum detection level (MDL) plots which depend on some basic array/system parameters, transmission loss and the (typically) anisotropic noise distribution.

Slides 36-40

MDL plots are presented for the various ocean environments.

Slides 41-46

MDL plots are presented for the various ocean environments with the addition of a discrete interferer.

Slides 47-57

The dependence of MDL on array orientation is shown.